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Human Health Risk Assessment Work Plan: Asarco East Helena Facility, East Helena, Montana

October 2009

Linda Jacobson (3 Copies)
RCRA Project Manager
US EPA Region VIII
8ENF-T
1595 Wynkoop Street
Denver, Colorado 80202-1129

October 8, 2009

SENT BY ELECTRONIC MAIL AND
CERTIFIED MAIL RETURN RECEIPT REQUESTED

Re: Human Health Risk Assessment Work Plan,
Asarco East Helena Facility, East Helena, Montana

Dear Ms. Jacobson:

Asarco herewith submits the Human Health Risk Assessment Work Plan (October 2009) for the Asarco East Helena Facility. A copy of the Work Plan is simultaneously being submitted in the enclosed compact diskettes. The Work Plan, compact diskettes, and the certification signed by an officer of ASARCO LLC (Asarco) are attached to this letter.

The Settlement Agreement requires advanced approval of activities and expenditures to be considered Response Costs. Now that the Human Health Risk Assessment Work Plan has been assembled, Asarco will develop an estimate of Work Plan proposed expenditures, which will be provided to EPA in the next few weeks. Asarco seeks written approval from EPA that preparation and implementation of the Human Health Risk Assessment Work Plan qualifies as Response Costs.

Please immediately notify me if have any questions on the Work Plan.

Sincerely,

Jon Nickel

Enclosures

CERTIFICATION
PURSUANT TO U.S. v ASARCO INCORPORATED
(CV-98-3-H-CCL, USDC, D. MONTANA)

I certify under penalty of law that this document, Human Health Risk Assessment Work Plan, (October 2009) and all attachment, were prepared under my direct supervision in accordance with a system designed to assure that qualified personnel gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine or imprisonment for knowing violations.

Signature _____
Name: Thomas L. Aldrich
Title: Vice President Environmental Affairs
Date: October 8, 2009

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Human Health Risk Assessment Work Plan: Asarco East Helena Facility, East Helena, Montana

Prepared for

ASARCO LLC
100 Smelter Road
PO Box 1230
East Helena, MT 59635

Prepared by

Exponent
15375 SE 30th Place, Suite 250
Bellevue, WA 98007

October 2009

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Acronyms and Abbreviations

BERA	baseline ecological risk assessment
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980
CoPC	chemical of potential concern
CSF	cancer slope factor
CSM	conceptual site model
EPA	U.S. Environmental Protection Agency
EPC	exposure-point concentration
ERA	ecological risk assessment
IEUBK	Integrated Exposure/Uptake Biokinetic (model)
HHRA	human health risk assessment
LCCCHD	Lewis and Clark City-County Health Department
LOAEL	lowest-observed-adverse-effect level
MCL	maximum contaminant level
MDEQ	Montana Department of Environmental Quality
MFWP	Montana Department of Fish, Wildlife and Parks
PRG	preliminary remediation goal
QC/QA	quality control/quality assurance
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
RI/FS	remedial investigation/feasibility study
RSL	risk-based regional screening level
UCL	upper confidence limit
USFWS	U.S. Fish and Wildlife Service

1 Introduction

The East Helena Smelter human health risk assessment (HHRA) will estimate the likelihood and magnitude of risks to potential human receptors posed by current or future exposure to chemicals in soil, water, sediments, and biota as a result of former plant operations. This risk assessment is being conducted as part of the Phase II Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) and will address chemicals at the site and in specific areas offsite that are otherwise not being addressed under the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) offsite investigations. The purpose of an HHRA is to support risk management decisions on any corrective measures that are needed to address potential human health risks. This work plan identifies and describes the tasks necessary to conduct the HHRA.

This HHRA work plan incorporates input from the U.S. Environmental Protection Agency (EPA) and other involved agencies as documented in letters from Linda Jacobson, U.S. EPA, to Jon Nickel of Asarco (Jacobson 2009a,b,c,d,e) and discussed in conference calls on April 30 and October 1, 2009 between U.S. EPA, Asarco, and other involved parties. The HHRA work plan was prepared in accordance with guidance set forth in U.S. EPA's (1989, 1991) *Risk Guidance for Superfund*, and includes:

- A general overview and background of the site, including the physical setting and current and future uses (Section 1)
- A summary and analysis of previous site investigations (Section 2)
- A preliminary screening of chemicals of potential concern (Section 3)
- A preliminary conceptual site model, including identification of the potential exposure pathways and receptors selected for analysis (Section 4)
- A description of the methodology and assumptions to be used in the HHRA (Section 5).

1.1 Site Overview

The Asarco East Helena facility was a former lead smelter, and is situated on approximately 142 acres near East Helena, Lewis and Clark County, Montana. The Facility was built in 1888 and operated by Asarco Incorporated from 1899 until its closure in April 2001. Currently, the facility site is undergoing decommissioning.

The East Helena facility property is bounded to the south by Upper Lake and Lower Lake, to the east and northeast by Prickly Pear Creek, and to the north by the City of East Helena and American Chemet (Figure 1). The town of East Helena and residential subdivisions border the northern boundary of the site. Land use surrounding the facility to the east and west includes agriculture and rangeland. The RFI also includes areas off the facility property that may be over the groundwater plume from the site or affected by current wind dispersion of site dust, and creeks or drainages affected by the facility.

The interior portions of the site were largely covered with buildings, paved with concrete, or otherwise developed. Many of these areas have undergone or are currently undergoing demolition. A large slag pile is situated in the northeast quadrant of the site. Wilson Ditch flows from Upper Lake across the site underground through an enclosed pipe emerging on the northwestern side of the site. Wilson Ditch is a man-made diversion ditch for irrigation and is wet only seasonally.

Aside from areas of past facility operations, the primary features at the site are the surface water bodies, Prickly Pear Creek, Lower Lake, Upper Lake, and the marshes surrounding Upper Lake. Surface water flow at the site is diverted from Prickly Pear Creek at the Upper Lake diversion, upstream of the Asarco facility site, and is regained by return surface water flow from Upper Lake, and groundwater inflow in the vicinity of Lower Lake. Water quality data and groundwater levels show evidence of stream flow loss in the area immediately downstream of the Asarco facility site. Dissolved and total metal concentrations have historically shown elevations in the reach of Prickly Pear Creek adjacent to the Asarco site. This increase has been attributed to historical seepage from Lower Lake via groundwater in the stream reach immediately adjacent to Lower Lake. However, upstream historical mining activities and other

sources also contribute to metal loading in Prickly Pear Creek and its associated drainage. These water bodies and associated habitat are described further in the Baseline Ecological Risk Assessment (BERA) work plan (Exponent 2009).

Numerous investigations and remedial actions have taken place at the site from the late 1980s to the present, which have altered site conditions over time (See summary in BERA work plan, Exponent 2009; Phase II RFI Characterization Plan, Hydrometrics 2009). Soil and sediment removal actions, changes in facility discharges, installation of treatment systems and Geomembrane caps, and storm water improvements are some of the remedial actions that have changed conditions and potential exposures at the facility over the past 20-plus years.

Future site use for the facility has not been determined. However, several future land use scenarios are being considered, including the following:

- Existing conditions. The site remains in its present, largely unused state. No significant actions that result in a change of future land use are implemented.
- Industrial use. A portion or all of the facility is used for industrial purposes. This might include reprocessing of slag or use of the area for warehouse or other industrial uses.
- Agricultural use. This scenario assumes that the facility would be capped and revegetated, with institutional controls that would ensure the integrity of the cap. This may limit future agricultural use to grazing of livestock.
- Recreational use. This scenario assumes that the facility would be capped and revegetated, and institutional controls would be put in place to ensure the integrity of the cap. This land use scenario assumes that the facility area is used occasionally for outdoor recreational purposes such as hunting, fishing, hiking, bird watching, etc.

2 Summary of Previous Investigations

Previous site characterization investigations have shown that site surface and subsurface soils contain elevated metals, of which arsenic, cadmium, copper, lead, and zinc show the highest concentrations (ACI 2005). Limited data on metals levels from onsite water bodies also indicated elevated levels of metals and exposures associated with these areas of the site (U.S. EPA 2005b). A number of investigations and evaluations have been conducted for the site that provide relevant data and information for the HHRA. Many of these investigations are related to the CERCLA activities offsite in the community. These are summarized below by topic.

2.1 Blood Lead Studies in East Helena

2.1.1 Centers for Disease Control 1983 Child Lead Study

In 1983, blood lead sampling was conducted on 91 percent of the population of children younger than age 6 years living in the East Helena area (CDC 1986). Mean blood lead levels were 13, 9.4, and 6.6 μg/dL, for children living in areas within 1 mile, 1 to 2.25 miles, and greater than 5 miles of the smelter, respectively. The maximum blood lead level was 33 μg/dL. The percentage of children with blood lead levels of 10 μg/dL or higher was 51 percent for the area within 2.25 miles from the smelter (LCCCHD 1991). In addition to distance from the smelter, this study also investigated relationships between blood lead level and lead levels in soil, house dust, and hand dust; behavioral factors such as mouthing, eating homegrown vegetables, taking vitamins, parental smoking; and property condition factors such as eroding paint, amount of ground cover in the yard, and presence of storm windows.

2.1.2 Lewis and Clark City-County Health Department (LCCCHD) 1991 Child Lead Study

A blood lead survey in 1991 reported considerably lower blood lead levels than the previous survey in 1983 (LCCCHD 1991). The mean blood lead level for young children within the

2.25 mile study area (N=171) had decreased to 4.75 μg/dL (range of <4 to 26 μg/dL) with half of the children having an undetectable blood lead level and 6 percent of children with a blood lead of 10 μg/dL or greater. The mean blood lead level within 1 mile of the smelter was 5.92 μg/dL, and of the control population was 3.65 μg/dL. This study also examined the effect of several factors on blood lead level including child characteristics and behavior, house location and characteristics, family hobbies, smoking in the home, and the presence of pets. The study concluded that factors contributing to blood lead levels included proximity to the smelter, smoking in the home, and history of an older sibling with an elevated blood lead level. The statistical analyses presented also indicated home age as having a dominant effect on blood lead level, among the factors analyzed.

2.1.3 LCCCHD Blood Lead Monitoring Program

Since May of 1995, the LCCCHD has maintained a blood lead monitoring and intervention program as a part of a joint effort among local, state, and federal agencies and Asarco (LCCCHD 1996). As summarized in Table 1, yearly blood lead samples in young children (ages 0–72 months) indicate continued decline in blood lead levels since 1995, with mean blood lead in the 1 to 2 μg/dL range during the past four years (LCCCHD 2009). No blood lead levels have been at or above 10 μg/dL since 2000, except one measurement of 12 μg/dL out of 133 measurements in 2008 (0.8 percent). Published summaries of results from this program (e.g., as presented in the proposed plan; U.S. EPA 2007a) include all blood lead measurements of young children who have exposure to the East Helena residential area. Each sample is thus not necessarily independent and may include multiple samples per child, especially in those who need follow up sampling after an elevated blood lead level is detected. Siblings of children with elevated blood lead levels or those living in older homes are also more likely to be encouraged to have their blood lead sampled. Depending on when the blood lead level was measured, seasonal access to lead in soil may also affect the results. However, these results provide ongoing information about blood lead trends in the community over time.

2.2 Remedial Investigation of Soils, Vegetation, and Livestock (1987)

The Remedial Investigation of Soils, Vegetation, and Livestock (CH2MHill 1987a) included the sampling and analysis of soils, plant tissues, and cattle resources from the site and throughout the Helena Valley. Along with the remedial investigation, two related reports, which were based on literature reviews, are summarized here as well:

- Assessment of the toxicity of arsenic, cadmium, lead, and zinc in soil, plants, and livestock in the Helena Valley of Montana (CH2MHill 1987b)
- Assessment of the toxicity of copper, mercury, selenium, silver, and thallium in soil and plants in the Helena Valley of Montana (CH2MHill 1987c).

The purpose of the 1987 remedial investigation of soils, vegetation, and livestock was to characterize the nature and extent of contamination in soil, vegetation, and cattle in the Helena Valley and to identify remedial action alternatives. Although dated, the 1987 remedial investigation also contains an extensive site description, a brief summary of site operations, maps and aerial photographs of the site and surrounding areas, local wind data, maps depicting distribution of various metals, human population data, wildlife and endangered species information, and an analysis of soil properties. No endangered species were reported to occupy the Helena Valley at the time of this report, although it is stated that migratory bald eagles or peregrine falcons could possibly enter and make use of habitat in the Helena Valley. The remedial investigation appendices include detailed sampling and analysis method descriptions, scientific names of plants sampled, soil descriptions and physical data, descriptions of the ranches and cattle sampled, statistical analysis results, and raw data for the soil, vegetation, and cattle investigations.

2.2.1 Soil Investigation

The following were the objectives of the CH2M Hill (1987a) soil investigation:

- Determine whether soil metals were elevated due to site contamination
- Map the spatial distribution of soil metals relative to the smelter
- Evaluate the horizontal and vertical distribution of metals in soil, and investigate soil properties that influence this distribution.

A total of 157 soil sample locations were sampled at a depth of 0–4 in. A subset of 47 locations were sampled to 30 in. depth, at intervals of 4–8, 8–15, and 15–30 in. A reference site located 27 miles southeast of the smelter was sampled to represent local background. Several metals occurred at concentrations exceeding background: silver, arsenic, cadmium, copper, mercury, manganese, lead, selenium, tin, thallium, and zinc. Exceedances ranged from 1.3 to 27 times as great as background. Soil metal concentrations tended to be elevated east of the smelter based on kriging analysis, which is consistent with the prevailing wind direction in the Helena Valley, from west to east. The highest metals concentrations occurred in the 0–4 in. layer, although some metals existed as deep as 30 in.

2.2.2 Vegetation Investigation

The following were the objectives of the CH2M Hill (1987a) vegetation investigation:

- Determine whether plants and grain heads in Helena Valley contain elevated metals
- Describe metal concentrations in plants in terms of phytotoxicity benchmarks and allowable concentrations in forage for livestock consumption
- Describe areal distribution of metals in plants
- Investigate the relationship between metals concentrations in soils and in plants.

The vegetation investigation compared plants and grains grown in the Helena Valley to the reference location 27 miles southeast of the smelter. Samples of forage, range grass, barley, and

wheat were collected from 58 sites corresponding to soil sample locations. Alfalfa, needle-and-thread grass, winter wheat, and barley all had elevated metals concentrations relative to background. Significant correlations were found between soil concentrations and total plant and grain-head metal concentrations.

2.2.3 Livestock Investigation

The following were the objectives of the CH2M Hill (1987a) livestock investigation:

- Determine whether cattle are exposed to site contaminants
- Investigate the level of exposure in terms of the spatial distribution of site-related contaminants
- Investigate the relationship between cattle exposure concentrations and soil and vegetation concentrations
- Describe the concentrations of metals in cattle tissue.

The livestock investigation looked at cattle whole blood, blood serum, and hair and compared metals concentrations in Helena Valley cattle herds to cattle herds from the reference location. Arsenic, cadmium, lead, and zinc were elevated in cattle whole blood compared to the reference location. Significant relationships existed between cattle blood lead concentrations and surface soil lead concentrations, although this relationship was not significant for arsenic, cadmium, or zinc. Arsenic and lead concentrations in cattle blood were greatest closer to the smelter and decreased with distance. This relationship was not significant for cadmium or zinc.
A relationship was also noted between cattle blood lead and vegetation lead concentrations.

2.2.4 Toxicity of Arsenic, Cadmium, Lead, and Zinc in Soil, Plants, and Livestock (1987)

This assessment of the toxicity of arsenic, cadmium, lead, and zinc in soil, plants, and livestock in the Helena Valley of Montana presented a literature review to assess candidate hazard levels

for metals associated with the site and the Helena Valley specifically (CH2MHill 1987b). Hazard levels were developed to assess risk to plants and livestock from metals in soil, plants, livestock, and water, and to determine potential impacts to agricultural resources. The literature review did not give greater importance to either field or laboratory studies and did not consider effects of metal interactions. Weight was added to studies that took place in the Helena Valley and/or contained conditions and/or species similar to those present in the Helena Valley.

The report listed background concentrations and toxicity data for each metal in numerous media in a series of tables. Media include livestock, plants, soil, and water. Regulatory criteria from other sources were also considered: land application of sewage sludge, coal overburden suitability for root-zone material, criteria defining hazardous wastes, and criteria for metal contaminants based on land use. The report also contained summaries of the toxicological mechanisms of each metal for both livestock and plants. "Tolerable levels" for plants and livestock were selected on the basis of the maximum concentrations at which no toxicity was noted. Selection of "toxic concentrations" was based on results of individual studies, as well as criteria reported as toxic in the literature. However, the regulatory and toxicological information are outdated and may not be relevant today.

2.2.5 Toxicity of Copper, Mercury, Selenium, Silver, and Thallium in Soil and Plants (1987)

The assessment of the toxicity of copper, mercury, selenium, silver, and thallium in soil and plants in the Helena Valley of Montana, prepared by CH2MHill (1987c), was the second of the volume of the report described above and contained similar information for these additional metals. This volume addressed soil and plants, unlike the first volume, which also included livestock.

2.3 Process Pond Remedial Investigation/Feasibility Study (1989)

The Process Pond Remedial Investigation/Feasibility Study (RI/FS) was prepared by Hydrometrics and Hunter/ESE (1989) for Asarco and addressed the first operable unit assigned to an accelerated schedule set by EPA and Asarco. The operable units for the site are listed as:

- Process Fluids (includes Process Ponds and Process Fluids Circuits sub-units)
- Groundwater
- Surface Soils/Surface Water (includes onsite soil, residential East Helena soils, limited Helena Valley Soils, Prickly Pear Creek, Wilson Ditch, Vegetation, Cattle, Fish, and Waterfowl sub-units)
- Slag Pile
- Ore Storage Areas.

The Process Pond operable sub-unit, which along with the Process Circuit sub-unit composed the Process Fluids Operable Unit, consisted of four process ponds: Lower Lake, the former speiss granulating pond and pit, the former acid plant water treatment facility, and former Thornock Lake. The other operable units were covered in the 1990 Comprehensive RI/FS. The Process Pond investigation included a water-balance investigation of the main process-water circuit for Lower Lake and a physical characterization of each pond. Physical characterization included the sampling of sediment, soil, process water, and process fluids. Information obtained to characterize the four ponds could be useful for considering the transport and fate of contaminants. The report included some information on contaminant distribution and toxicology data (see description of Endangerment Assessment below); however, much of the report dealt with remediation issues and is not pertinent to HHRA.

The endangerment assessment portion of the Process Pond RI/FS (Section 5.0 of the Process Pond RI/FS) identified the metals of concern for public health and the environment as arsenic, cadmium, copper, lead, and zinc. A non-site-specific toxicity assessment, describing health and

environmental hazards of each chemical of concern, was given. These assessments included information on criteria and standards, toxicodynamics, and information on effects to aquatic and terrestrial organisms.

2.4 Comprehensive RI/FS (1990)

The Comprehensive RI/FS (Hydrometrics 1990) covered the following operable units of the site:

- Groundwater
- Surface Soils/Surface Water (included onsite soil, residential East Helena soils, limited Helena Valley soils, Prickly Pear Creek, Wilson Ditch, vegetation, cattle, fish, and waterfowl sub-units)
- Slag Pile
- Ore Storage Areas.

The Process Fluids operable unit was evaluated in the 1989 Process Pond RI/FS and summarized in the 1990 Comprehensive RI/FS. Groundwater under the site was reported to have been affected by process fluids and other site operations resulting in leaching of constituents. The slag pile was reported to have had little effect on leaching of metals to groundwater or in contributing to airborne concentrations of metals. The ore storage areas had elevated concentrations of metals in soil and were identified for remedial actions.

The Surface Soils/Surface Water investigation provided the most information of relevance for the risk assessment and addressed the following:

- Soil samples from the site and from other locations in East Helena
- Water samples from Prickly Pear Creek, Upper Lake, and Wilson Ditch
- Groundwater/surface water interactions at Prickly Pear Creek

- Surface-water drainage mapping and double-ring infiltrometer test
- Vegetable samples from residential gardens and grain samples from Helena Valley
- Helena Valley cattle
- Fish in Prickly Pear Creek and Lake Helena
- Waterfowl/sediment comparison literature review
- A biological inventory for Upper Lake.

The Surface Soils investigation was conducted to determine the nature and extent of metals in surface soils at the site and in the East Helena area, extent of wind dispersion of soil particulates, and the amount of contaminated surface soil that could enter Prickly Pear Creek during a storm event.

The Surface Water investigation was conducted to measure flow/seepage, surface water quality, and metals in sediment. The investigation also measured surface water/groundwater interrelationships, provided an evaluation of surface water uses, and evaluated the flux of contaminated soils entering Prickly Pear Creek during runoff events. Surface water was sampled from Prickly Pear Creek, Upper Lake, and irrigation ditches. Sediment was sampled from Prickly Pear Creek, Wilson Ditch, and Upper Lake. Surface water/groundwater interrelationships were investigated via continuous water level recorders installed in monitoring wells located at Prickly Pear Creek, in shallow aquifer, in intermediate aquifer, and in East Helena north of Highway 12. Surface water drainage on the site, in catchment basins, and offsite runoff areas was assessed to determine frequency of water retention and fate of runoff.

The Vegetation Investigation was conducted to determine commercial and residential production and consumption patterns of food crops and to determine metal concentrations in plant tissue.

The Cattle Investigation was conducted to determine production and consumption patterns of locally grown beef and to determine metals concentrations in beef. Cadmium was reported to be elevated in kidney and liver of Helena Valley cattle; however, levels in the control herd from Townsend were similar or in some cases higher.

Fish were sampled from Prickly Pear Creek and Lake Helena and analyzed for metals. In Prickly Pear Creek, brook trout and rainbow trout were targeted, but only brown trout were captured. In Lake Helena, carp, brown trout, and rainbow trout were targeted. No carp were captured, but brook trout, brown trout, white sucker, and longnose sucker were sampled. Arsenic and other metals concentrations in Prickly Pear Creek and Lake Helena fish tissue were stated to be low and typical for fish in Montana.

A literature review was conducted to determine potential exposure pathways for waterfowl. Exposure via surface water and sediment were the media considered. The goal of the assessment was to determine potential exposure of humans to metals in waterfowl tissue.

2.5 Metal Residues in Sediment and Biota from Prickly Pear Creek and Lake Helena (1997)

This U.S. Fish and Wildlife Service report, titled "Biological Indices of Lead Exposure in Relation to Heavy Metal Residues in Sediment and Biota from Prickly Pear Creek and Lake Helena, Montana," investigated metal exposure in benthic invertebrates and fish in Prickly Pear Creek, both upstream and downstream of the site, and in mallard ducks in Lake Helena (downstream of the site) and Canyon Ferry Lake (a reference site). The study also measured metals concentrations in sediment in Prickly Pear Creek and found no significant difference in concentrations of arsenic, cadmium, copper, lead, or zinc in samples collected upstream and downstream of the site. These metals, however, were elevated in the vicinity and immediately downstream of the site.

Whole-body fish and benthic invertebrate samples were collected and analyzed, and concentrations of arsenic, copper, lead, and zinc were found to be significantly higher

downstream of the site in stonefly larvae. Significant differences were not observed in miscellaneous benthic invertebrates, rainbow trout, brook trout, and sculpin, although concentrations from animals taken below the site were elevated compared to above the site. (It is important to note that, throughout the report, differences between upstream and downstream data sets that were determined to not be statistically significant are still described as "elevated.")

Blood lead levels in mallard ducks were measured and found to be elevated at both site and reference locations.

The study concluded that some metals were elevated below the site relative to reference conditions and that this was partially reflected in the biota. Recommendations were made to continue cleanup of the Corbin-Wickes historical mining district to reduce metals input into Prickly Pear Creek and Lake Helena, to monitor aquatic biota to document lead exposure, and to further investigate sediments in Lake Helena and Prickly Pear Creek.

2.6 Supplemental Ecological Risk Assessment (2005)

The Supplemental Ecological Risk Assessment (ERA) (U.S. EPA 2005b) was conducted by U.S. EPA Region 8 to address data gaps in the 1987 remedial investigation, specifically to gather data on the habitat, and on contaminant concentrations in the onsite lakes (Lower Lake and Upper Lake), Prickly Pear Creek, and the marsh area, as well as reference sites, including Canyon Ferry Reservoir and Prickly Pear Creek upstream of the site.

Data that were used in the Supplemental ERA included surface water, sediment, sediment porewater, aquatic plants, aquatic invertebrates, and fish. Samples were analyzed for metals concentrations, sediment toxicity (amphipod [*Hyalella azteca*] subchronic growth and survival test), and benthic macroinvertebrate community structure (density and diversity of species). The Supplemental ERA addressed exposure to fish, benthic invertebrates, terrestrial plants, terrestrial soil invertebrates, wildlife (birds and mammals), and livestock. The ERA used data collected by EPA in their 2003 field study for surface water, sediment, sediment toxicity, sediment porewater, benthic invertebrate tissue, benthic invertebrate community assemblage,

fish tissue, and aquatic plants. EPA also used fish tissue and benthic invertebrate tissue data collected earlier by the U.S. Fish and Wildlife Service (USFWS 1997) for their 1997 study titled, "Biological Indices of Lead Exposure in relation to Heavy Metal Residues in Sediment and Biota from Prickly Pear Creek and Lake Helena, Montana." The Supplemental ERA used data from seven benthic invertebrate tissue samples collected by USFWS and three collected by EPA. For fish tissue, the Supplemental ERA used data from fifteen samples collected by USFWS and eight samples collected by EPA.

The risk assessment for aquatic receptors incorporated several lines of evidence each and applied a hazard quotient approach. The lines of evidence considered for aquatic receptors included analysis of metals concentrations in surface water, sediment, and sediment porewater, site-specific sediment toxicity testing with benthic invertebrates,[1] evaluation of fish exposure via ingestion of food and incidental ingestion of sediment, and evaluation of body burdens of aquatic organisms.

For aquatic receptors, the following levels of risk of population-level effects to fish and benthic invertebrates were identified:

- Moderately high for fish and high for benthic invertebrates in Lower Lake
- Minimal to low for fish and low for benthic invertebrates in Upper Lake and the marsh area
- Minimal for fish and minimal to low for benthic invertebrates in Prickly Pear Creek.

Levels of concern for human health from contaminants in fish tissue are thus likely to be greater for Lower Lake (if fish are present) than for Upper Lake or Prickly Pear Creek.

[1] Sediment toxicity testing was limited to the *Hyalella azteca* 10-day survival and growth test; samples were collected from Lower Lake, Upper Lake/Marsh, and two Canyon Ferry Reservoir reference sites.

2.7 1995 Offsite Residential Area Risk Assessment

The most recent comprehensive risk assessment of the offsite residential area was conducted in 1995 (Kleinfelder and Hydrometrics 1995). This study assessed the risks of residual metals in residential soil in the community after expedited removals and remediation of all properties with lead levels in excess of 1,000 ppm. Lead, arsenic, and cadmium were selected as chemicals of concern for evaluation in the risk assessment. Antimony, total chromium, copper, manganese, mercury, selenium, silver, thallium, and zinc in soil were eliminated from further evaluation based on the screening of maximum concentrations against risk-based values. The maximum value of cadmium did not exceed its screening concentration in soil but it was retained for evaluation of airborne dust inhalation and local food pathways of exposure. The following potential pathways of exposure were considered:

- Incidental ingestion of and dermal contact with outdoor soil or indoor dust
- Ingestion of homegrown vegetables
- Inhalation of particulates in air
- Ingestion of locally raised beef or grain
- Incidental ingestion of water from Prickly Pear Creek or Wilson Ditch
- Incidental ingestion of and dermal contact with sediments from Prickly Pear Creek or Wilson Ditch
- Ingestion of fish from Prickly Pear Creek
- Incidental ingestion of road and alley soils
- Ingestion of groundwater.

Of these pathways, exposure to Wilson Ditch sediments and water was eliminated because this area had been remediated. Ingestion of groundwater was eliminated because contaminated groundwater was not being used as a source of drinking water. Other pathways were discussed qualitatively in the report and not found to be of sufficient concern to include in the risk

assessment calculations. These included dermal contact with soils or sediment, ingestion of locally grown grain and beef, ingestion of water, sediment, and ingestion of fish from Prickly Pear Creek. Risks associated with incidental ingestion of soil and dust, homegrown vegetable intake, and airborne dust inhalation were therefore quantified.

To assess health risks from lead, the risk assessment ran the EPA child lead model for each property in the community. The model predicted a community-wide geometric mean blood lead level of 2 to 3 μg/dL, with an average risk of exceeding a 10 μg/dL blood lead level of 0.45 to 2 percent. Depending on the model assumptions, the model estimated that 3 to 13 percent of the yards in the community would have a greater than 5 percent risk of exceeding a 10 μg/dL blood lead level. The risk assessment also evaluated the relationship between soil lead concentration and measured blood lead concentrations for children in the community. For soil lead levels below 1,000 ppm, no correlation between blood lead level and soil lead level was apparent.

Arsenic cancer risks were predicted to range from 3 in 100,000 to 9 in 100,000. Risks associated with incidental soil ingestion were more than 17 times as great as those for eating garden vegetables. Inhalation risks were similar to those of soil ingestion. Cadmium risks for inhalation were one third of those for arsenic.

2.8 Offsite Risk Assessment Reports Subsequent to 1995

Since the 1995 risk assessment for the offsite residential area (Kleinfelder and Hydrometrics 1995), several reports updating or revising the risk assessment calculations for the offsite area have been produced by EPA and Asarco.

2.8.1 Hydrometrics Residential Risk Assessment Reevaluation

Revised risk assessment calculations for exposure to lead, arsenic, and cadmium in the offsite residential area were conducted by Hydrometrics (1998) based on the 1995 risk assessment. The purpose of this revised assessment was to address whether risks and remedial actions (particularly for arsenic and cadmium) needed to be reassessed, given the revised remediation

plan established in a modified EPA Administrative Order on Consent. The revised remediation plan specified that yards would not be remediated unless or until a child resided at that location. Consequently, this report addressed concerns that elevated risks from arsenic and cadmium may exist in the interim period before all yards exceeding the 1,000 ppm cleanup level for lead were remediated, as assumed in the 1995 risk assessment. Calculations focused on exposures to older children and adults because properties with younger children were to be remediated. Exposure concentrations were calculated as the 95th percentile upper confidence limit (95%UCL) on the mean for different neighborhood areas, including samples on unremediated and remediated yards. EPA default assumptions for average and reasonable maximum exposure for ages 7 through adult were used in the calculations, along with the assumption of 80 percent gastrointestinal absorption of arsenic in soil. Risks for the soil ingestion pathway for arsenic (7×10^{-5} or less) and the noncancer hazard for cadmium and arsenic (0.02 or less) were stated to be minimal.

2.8.2 EPA Evaluation of a Preliminary Remediation Goal for Arsenic in Residential Soil

EPA and their contractor calculated a preliminary remediation goal (PRG) for arsenic in soil based on the 1995 risk assessment, incorporating revised assumptions for the ratio of arsenic in indoor dust to outdoor soil and oral bioavailability of arsenic in soil. The results of these calculations were presented in several memoranda (Hammon 1999; Brattin 1999; Hammon and Brattin 2001) and summarized by EPA's proposed plan (U.S. EPA 2007a) and Final Record of Decision for the offsite area (U.S. EPA 2009a). EPA and their contractor revised the ratio for arsenic in indoor dust relative to outdoor soil from the default of 1 to 0.5, based on experience at other mining and smelting sites in the region for which this ratio is "rarely greater than 0.5, and is often lower." Similarly, the bioavailability assumption was revised from the default of 0.8 to 0.5 (50 percent) based on measurements at other mining and smelting sites for which the bioavailability is "rarely greater than 0.5, and is usually lower." The resulting PRG for arsenic in residential soil was 176 ppm based on a 1.499×10^{-4} risk (U.S. EPA 2007a).

2.8.3 U.S. EPA (2005a) Re-Evaluation of the Cleanup Level for Lead in Soil

U.S. EPA (2005a) re-evaluated the cleanup level for lead in residential soil based on the 1995 offsite risk assessment, more recent agency guidance, and additional site-specific data collection regarding the ratio of lead in indoor dust relative to outdoor soil, and *in vitro* testing of the relative bioaccessibility of lead in soil.

House dust samples were collected at 30 homes in East Helena that were selected to be representative of the range of yard soil concentrations and locations in the community. Interior dust lead concentrations and lead loading in dust (i.e., mass of lead per square area) were weakly correlated. House dust lead concentration was related to the lead concentration in yard soil by a slope of 0.17 and an intercept of 271 ($R^2 = 0.0867$). The increase in lead loading with increase in soil concentration was similarly low and poorly correlated. Details of this investigation were reported by CDM (2004a,b; cited by U.S. EPA 2005a). Although the ratio of lead in dust to lead in soil of 0.17 is much lower than the EPA lead model default of 0.7, EPA noted that this low ratio is similar to those observed at other mining and smelting sites in the Rocky Mountain region.

EPA also conducted relative bioaccessibility testing of lead in soil based on soil samples from 20 residential properties in East Helena representing a range of lead soil concentration values and different areas of the site. The results of this analysis indicated an average relative bioavailability described as slightly higher than the default of 60 percent (71 percent). Based on this relative bioavailability, the absolute oral absorption for lead in soil would be 35.5 percent compared to the 30 percent default. Details of this investigation were reported in Drexler (2004; cited by U.S. EPA 2005a).

In their revised evaluation of lead in soil using their Integrated Exposure/Uptake Biokinetic (IEUBK) model, EPA used an air concentration of 0.1 $\mu g/m^3$ based on half the average for the Manlove sampling station east of the smelter facility between 1998 and 2001. Half this value was selected because smelter closure in 2001 and onsite remediation activities were expected to decrease air lead levels from site related sources.

Based on the site-specific oral bioavailability value (71 percent), indoor to outdoor soil lead ratio (0.17) and air lead level (0.1 $\mu g/m^3$) with all other inputs as default values, EPA calculated a lead cleanup level of 520 ppm. EPA also calculated a range of potential cleanup levels by varying some additional parameters, including the soil ingestion rate (default versus measurements in Anaconda) and the Geometric Standard Deviation (default versus an estimate based on other sites). The range of possible cleanup levels from this analysis was 250 ppm to 3,200 ppm with an average of 1,200 ppm and a geometric mean of 990 ppm. The selection of the cleanup level for the site was stated to be a risk management decision.

2.8.4 U.S. EPA (2007a) PRG Calculations for Lead and Arsenic in Offsite Soil for Occupational or Recreational Exposure Scenarios

EPA used their Adult Lead Model to calculate risk-based PRGs for lead in offsite soil under occupational or recreational exposures (Brattin 2007). Both scenarios for lead incorporated a relative oral bioavailability of 71 percent instead of the 60 percent default, based on the site-specific *in vitro* bioaccessibility results. The occupational scenario otherwise included model defaults for a worker. The recreational scenario assumed 150 days per year of exposure at the same average soil ingestion rate as a worker (50 mg/day). For arsenic, the relative oral bioavailability of 50 percent was used, consistent with the offsite residential assessment (e.g., Hammon and Brattin 2001). The rest of the assumptions for the worker were EPA default values with either no indoor dust exposure or no difference in concentration of arsenic in indoor dust versus outdoor soil.

2.8.5 Evaluation of the Contribution of Lead in Air and in Soil to Blood Lead Levels

An evaluation was conducted of the relative importance of lead in air and in soil to blood lead levels of children living in East Helena, based on historical data on air lead levels from 1981 to 1991 and on blood lead surveys conducted in 1983 and 1991 (SRC 2009). This analysis determined that the contribution of air lead (in $\mu g/m^3$) to blood lead level ($\mu g/dL$) was a factor of 1.38 and that of soil lead (in ppm) was a much smaller factor of 0.002656. At a soil lead

level of 1,000 ppm and an air lead level of 1.83 $\mu g/m^3$ in 1991, the contribution of air lead and soil lead to the blood lead level would be approximately equal. The report concluded that air lead levels in past years were a predominant contributor to blood lead levels.

2.9 Recent Onsite Facility Investigations

As summarized by the *Phase II RCRA Facility Investigation Site Characterization Work Plan*, additional site investigation of soil, groundwater, and surface water has been conducted since 1990, and is ongoing for groundwater and surface water (Hydrometrics 2009). A number of remedial activities have also been conducted onsite and these are described in Hydrometrics (2009).

2.10 Summary of Data Gaps from Previous Investigations

The review of the previous investigations revealed the following data gaps, which the additional planned characterization and HHRA will address:

- Soil sampling is lacking for the onsite residential area (Asarco housing)
- Previous studies did not assess the complete list of 19 metal analytes
- Detection limits were not sufficiently low in some of the previous studies to characterize exposure and risk
- Previous investigations did not adequately characterize all the relevant exposure areas for the site (e.g., few samples for certain exposure areas, no bank samples, limited fish tissue data set to characterize site-related exposures to anglers).

3 Identification of Chemicals of Potential Concern

Existing site data for chemicals detected in surface soil, sediment, surface water, groundwater, and offsite air monitoring data were screened to identify a preliminary list of chemicals of potential concern (CoPCs) for human health. The CoPC screening is used to focus the risk assessment on chemicals at the site that have the greatest potential to contribute to human health risks. The result of the human health CoPC screening is the identification of a site-specific list of chemicals on which the remainder of data evaluation and the risk assessment are focused.

The CoPC screening approach in the HHRA will be consistent with EPA guidance (U.S. EPA 1989; U.S. EPA 2002; U.S. EPA 1994a). For preliminary screening of existing surface soil and sediment data, maximum site concentrations were first compared to regional mean background concentrations for selected metals collected in the Helena Valley (MDEQ 2007) and a statewide 95%UCL on the mean for background arsenic (MDEQ 2005). If a chemical concentration exceeded background, or if a regional background concentration was not identified, site concentrations were compared to health-protective risk-based Regional Screening Levels (RSLs; U.S. EPA 2009b). For surface water and groundwater, site concentrations were compared to federal Maximum Contaminant Levels (MCLs). If a chemical did not have an MCL, site concentrations were compared to RSLs protective of domestic tap water consumption (U.S. EPA 2009b) and Montana Water Quality Standards (MWQS) for surface water and groundwater (MDEQ 2008). Offsite air data were compared to RSLs and, for lead, to the National Ambient Air Quality Criterion. Soil concentrations onsite were also compared to EPA RSLs for soil that are protective of airborne dust exposure from resuspended soil particles. A more detailed comparison of site concentrations to background levels may be conducted in the HHRA if sufficient reference area data are available as a result of the additional Phase II RFI sampling. This comparison will follow the guidance of U.S. EPA (2002).

Per EPA guidelines, with the exception of lead RSLs based on noncancer health effects were divided by an additional safety factor of 10 to ensure that any potential additive effects from multiple CoPCs will still result in a hazard index less than 1. The lead RSLs were not divided by 10 because they are not based on a hazard index methodology, but rather on modeled blood

lead (as described in Section 5). For all media, duplicate samples were averaged for the data screening (using one-half the detection limit for undetected results).

The CoPC screening results are presented in Tables 2 through 7 and summarized below. In addition, a more detailed version of the CoPC screening results is provided in Appendix A, showing area-specific screening for soil, sediments, and surface water. In the remainder of this section the site data used in the screening are described, followed by a summary of screening results.

3.1 Available Site Data Sets

The most recent and representative surface soil, shoreline sediment, surface water, groundwater, and air data were compiled for the screening process to identify CoPCs. Earlier historical data for air and process water during plant operations or soil data from areas that have since been remediated were not used because they are not representative of current conditions. Samples of surface water, sediment, and surface soil were collected in 2001 as part of the Phase I RFI. Surface water and sediment were also sampled in 2003 as part of the field studies conducted for the Supplemental ERA. In addition, recent surface water and groundwater data are available from the ongoing Comprehensive post-RI/FS monitoring program for the site. These data were used in the screening process to identify CoPCs for the site, and are summarized in the sections below. This screening process will be repeated in the risk assessment once the additional site characterization data are available (see Phase II RFI Characterization Work Plan; Hydrometrics 2009)

Because metals are the site-related chemicals of concern, the evaluation of the existing data was limited to the following list of 19 metals when sampled in the data sets:

Aluminum	Antimony	Arsenic
Barium	Beryllium	Cadmium
Chromium	Cobalt	Copper
Iron	Lead	Manganese
Mercury	Nickel	Selenium
Silver	Thallium	Vanadium
		Zinc

3.1.1 Surface Soil Data

Surface-soil samples were collected in 2001 as part of the Phase I RFI. For screening purposes, surface-soil[2] data were limited to those samples that were collected from unpaved areas on the site. Samples from areas that have been remediated or areas that are covered (e.g., capped) were not included. Existing and planned surface soil sample locations are shown in Figure 2. Surface soil samples that were used in the screening were collected from the following locations:

- Unpaved portions of the Lower Ore Storage Area (identified as LOS)
- The area between Upper and Lower Lakes (also called Tito Park, identified as UOS)
- The railcar staging area (identified as RCSA)
- Unpaved areas within the site boundary (identified as UPS)
- Unpaved areas adjacent to the site boundary, or facility perimeter samples (identified as UOP)
- Onsite rail corridor surface soil (identified as RC-SS).

[2] Only surface depth interval samples were included in the data screening. For the 2001 RFI data, this is typically the 0- to 4-in. interval, although some 0- to 1-in. samples were also included (refer to Table 5).

These data included arsenic, cadmium, copper, lead, and zinc, which have been the primary focus for soil sampling. Additional samples to be collected as a part of the Phase II RFI will include the other metals listed above.

3.1.2 Sediment Data

The more recent 2003 sediment data set from the Supplemental ERA (U.S. EPA 2005b) was used in chemical screening. Sediment samples were collected from Prickly Pear Creek, Lower Lake, and Upper Lake and the marsh area, at the same stations identified above for surface water (Figure 3). However, the 2005 Supplemental ERA did not include sediment data for Wilson Ditch.

3.1.3 Surface Water Data

The most recent surface water data are available for Prickly Pear Creek and Lower Lake from the ongoing Comprehensive Post-RI/FS monitoring program for the site. Prickly Pear Creek monitoring station locations are identified as PPC-3A (upstream of the site), PPC-103 and PPC-5 (adjacent to the site), and PPC-7 and PPC-8 (below the site) (Figure 4). The 2008 data from the monitoring program were included in the preliminary CoPC screening.

Surface water from Prickly Pear Creek, Lower Lake, and Upper Lake was also collected in 2003 as part of the Supplemental ERA. Five stations were sampled in Prickly Pear Creek, including one upstream of the site (identified moving downstream as PPC 1 through 5). Three stations were sampled in Lower Lake (LL 1 through 3), and 12 stations were sampled in Upper Lake and the marsh area (ULM 1 through 12) (Figure 3).

Surface water samples were also collected in 2001 and 2002 from Upper Lake and Wilson Ditch as part of the Phase I RFI. Surface water samples were collected at two historical Wilson Ditch monitoring locations: the ditch intake at Upper Lake (WD-1), and a monitoring point downgradient of the Asarco site (WD-2) (ACI 2005). The Wilson Ditch monitoring locations are shown in Figure 4.

The parameter list for surface water monitoring at the site includes field-measured parameters (pH, specific conductance, dissolved oxygen, and water temperature), general physical parameters (total dissolved and suspended solids), major anions (e.g., sulfate, chloride), and total recoverable metals, as well as dissolved metals. For the Supplemental ERA, surface water was analyzed for the full suite of both total and dissolved metals.

3.1.4 Groundwater data

Recent groundwater data are available for the site from the ongoing Comprehensive Post-RI/FS monitoring program. The groundwater monitoring network locations are shown on Figure 5. Two sets of groundwater data were used for screening: offsite private well data, and on- and offsite monitoring well data. For both data sets, the recent data from each well location was included in the screening. Data from 2007 to 2009 were included, because not every well was sampled in 2008–2009.

3.1.5 Air Data

Current air monitoring data are unavailable. Air data for some metals from monitoring locations in the East Helena community are available from the U.S. EPA Air Quality System from 1992 to 2000, and from a subset of monitoring stations in 2001 (Jeffrey 2009). Therefore, for the purpose of screening, the most recent data collected in 2000 at the Firehall monitoring station were used. The Firehall station is adjacent to and downwind from the site, and typically had the highest measured concentrations among the offsite monitoring stations. In addition, the Firehall data set includes the largest list of analytes: arsenic, cadmium, chromium, copper, lead, nickel, and zinc. Use of this data set will also provide a conservative screening because it was collected prior to closure of the smelter. The air pathway for other constituents onsite in soil can also be screened by comparing soil concentrations to EPA RSLs based on resuspension of dust and exposure via inhalation.

3.2 Surface Soil Screening

The results of the surface soil data screening are presented in Table 2 for residential and industrial exposure. More detailed area-specific screening results are provided in Table A-1 in Appendix A. Residential and industrial screening levels are based on either the EPA RSL for residential or industrial soil exposure (U.S. EPA 2009b), respectively, or Montana background, whichever is greater. RSLs based on noncarcinogenic effects were divided by 10, with the exception of the lead screening level. Background is based on mean soil concentrations from Helena Valley (MDEQ 2007). The arsenic background concentration represents the 95%UCL on the mean of background soil arsenic concentrations in Montana (MDEQ 2005).

Only arsenic, cadmium, copper, lead, and zinc were analyzed in surface soils. The maximum concentration for all metals exceeded available regional mean background concentrations and residential and industrial RSLs for soil. The maximum concentrations for arsenic and cadmium exceeded both the residential and industrial soil screening levels (EPA RSLs) for inhalation of resuspended soil particles. Copper, lead, and zinc lacked soil RSLs for inhalation of dust.

3.3 Sediment Screening

Sediments were screened using the same assumptions and screening criteria as for surface soil, described above (Table 3; see also Tables A-2 and A-3 in Appendix A). The maximum concentration for all metals exceeded available regional mean background concentrations. The following metals were present at concentrations exceeding the residential screening levels: aluminum, antimony, arsenic, cadmium, cobalt, copper, iron, lead, manganese, mercury, selenium, silver, thallium, vanadium, and zinc. Although the maximum concentrations of aluminum, iron, silver, and zinc exceeded one-tenth the residential RSLs, they did not exceed the RSLs themselves. Eight metals exceeded industrial screening levels: antimony, arsenic, cadmium, cobalt, lead, manganese, mercury, and thallium. Maximum concentrations of cobalt, manganese, and mercury exceeded one-tenth the industrial RSLs, but were below the RSLs themselves.

3.4 Surface Water Screening

MCLs for each constituent were used as the surface water screening level. If a constituent lacked an MCL, the surface water screening level was the lesser of the MWQS for human health (MDEQ 2008) and the RSL for tap water (U.S. EPA 2009b). RSLs based on noncarcinogenic effects were divided by 10, with the exception of the lead screening level.

Nine metals were detected at maximum concentrations that exceeded surface water screening levels: antimony, arsenic, cadmium, cobalt, iron, lead, manganese, selenium, and thallium (Table 4; see also Table A-4 in Appendix A). Detected results for vanadium were below the screening level, but for some undetected results the detection limit (25 μg/L) exceeded the screening level (18 μg/L). Mercury was not detected in any sample, but the detection limit (3 μg/L) slightly exceeded the screening level (2 μg/L). All metals that did not exceed an MCL also met the MWQS.

3.5 Groundwater Screening

The MCL was used as the groundwater screening level for both private wells and monitoring well data. If a constituent lacked an MCL, the groundwater screening level was the lesser of the MWQS for human health (MDEQ 2008) and the RSL for tap water (U.S. EPA 2009b). RSLs based on noncarcinogenic effects were divided by 10, with the exception of the lead screening level. In all cases the MWQS values are greater than or equal to the MCL.

Three metals were detected at maximum concentrations in offsite private wells that exceeded groundwater screening levels: arsenic, selenium, and vanadium (Table 5; see also Table A-5, Appendix A). Cobalt and mercury were not detected in any samples but the detection limit for some samples exceeded the screening level.

Thirteen metals were detected in monitoring wells at concentrations exceeding groundwater screening levels: aluminum, antimony, arsenic, cadmium, cobalt, iron, lead, manganese,

mercury, selenium, thallium, vanadium, and zinc (Table 6; see also Tables A-6 and A-7, Appendix A).

3.6 Air Screening

As noted above, the maximum detected soil concentrations for arsenic and cadmium were also compared with EPA RSLs that were based on air reference concentrations or inhalation unit risk factors (Table 2). No inhalation RSLs were available for copper, lead, and zinc. The maximum concentrations for arsenic and cadmium exceeded both the residential and industrial soil screening levels for dust inhalation.

Data used for screening also included annual average air concentrations of arsenic, cadmium, chromium, copper, lead, and zinc from the air monitor with the highest results in the community from the latest year of sampling (2000 at the end of smelter operations). These levels were screened against their respective air RSLs or the National Ambient Air Quality air standard for lead (0.15 $\mu g/m^3$ as a 3-month rolling average) (Table 7). Air concentrations of arsenic, cadmium, chromium, and lead exceeded these screening levels. No RSL air values were available for copper, lead, and zinc.

4 Preliminary Human Health Conceptual Site Model

A conceptual site model (CSM) is a planning tool used for identifying chemical sources, complete exposure pathways, and potential receptors on which to focus the risk assessment. The human health CSM describes the ways in which people could potentially be exposed to site-related chemicals. The preliminary CSM, developed at the start of the assessment, reflects an understanding of the site prior to a more in-depth analysis of environmental chemical concentrations and prior to screening for CoPCs in the HHRA. The purpose of this step is to ensure that all potential pathways are considered, regardless of whether those pathways are complete. An exposure pathway is the course a chemical takes from a source to an exposed receptor. Exposure pathways consist of the following four elements: 1) a source; 2) a mechanism of release, retention, or transport of a chemical to a given medium (e.g., air, water, soil); 3) a point of receptor (human or ecological) contact with the medium (i.e., exposure point); and 4) a route of exposure at the point of contact (e.g., incidental ingestion, dermal contact). If any of these elements are missing, the pathway is considered incomplete (i.e., it does not present a means of exposure). Only those exposure pathways judged to be potentially complete are of concern for human exposure. The preliminary human health conceptual site model is presented in Figure 6.

4.1 Site Uses and Potentially Exposed Populations

The following site use scenarios and receptors were considered for the human health risk assessment:

Current—The facility is fenced and has and will continue to undergo demolition of smelter structures. The area northwest of the facility continues to be occupied by American Chemet. Offsite residential areas were evaluated as part of the residential HHRA (Kleinfelder and Hydrometrics 1995). Several company-owned residences (Asarco Housing) are located at the northeast corner of the facility. Young children are not currently allowed to live in these residences. Other surrounding land uses are predominantly

agricultural or open space. The receptors under current use conditions include: onsite residents (older children and adults), industrial workers (adults), and occasional trespassers (older children and adults). In addition, exposure of offsite residents to CoPCs in air and groundwater will be considered.

Future—Under the most likely future use scenarios, the site would retain its current use, or may be used for industrial, agricultural (i.e., grazing), or recreational purposes. The receptors that will be evaluated in HHRA under future use conditions include: onsite residents (all ages), industrial workers (adults), ranchers who graze their cattle onsite (adults), and recreational users/trespassers who live in the area (older children and adults).

Individual exposure units within the site will be identified based on site characteristics, including expected site use, topography, and media concentrations (from the Phase II RFI data collection and relevant historical data).

4.2 Exposure Pathways

An exposure pathway describes a chemical's transport from its source to a potentially exposed individual and must include a source, transport mechanism, receptor, and point of entry into the body. Potential exposures associated with the chemicals identified at the property are evaluated by identifying current and potential future uses of the property, those populations that could be exposed to the chemicals (i.e., the receptors), and the manner in which they may be exposed (i.e., the exposure pathway). The following scenarios and potentially complete exposure pathways were identified by the preliminary conceptual site model:

4.2.1 Onsite Resident

Under both current and future use scenarios residents of existing onsite housing could be exposed to site CoPCs through direct contact with residential soil (ingestion, inhalation, and dermal contact) or consumption of homegrown vegetables. Currently, young children are not allowed to live in the onsite housing. Thus, under the current use only

adult residents (including older children, i.e., > age 6) are exposed. However, in the future it is possible that young children could reside in onsite housing, necessitating the consideration of all ages. Groundwater is not a source of domestic water for the facility owned housing, and because of the availability of municipal water, there is no reason to expect groundwater to be used for this purpose in the future.

Of the potentially complete exposure pathways identified for onsite residents, soil ingestion is considered the most significant source of exposure. Exposure to metals following re-suspension of dust from soil has a limited influence on risk estimates for metals in soil. Relatively little inhaled dust passes into the lower respiratory tract and lungs, where absorption could potentially occur. Both chemical and physical properties of the inhaled substance play a role in the biological fate of inhaled particles, but particle size is the most important factor for metals sorbed to dust and soil. Inhaled particles greater than 1 micron (micrometer) in diameter, which make up the majority of soil and dust in most environmental settings, are largely transported into the gastrointestinal tract (U.S. EPA 2003)

Dermal contact with metals in soil may also result in additional exposure. However, non-lipophilic compounds such as metals are only minimally absorbed. EPA recognizes this in *Risk Assessment Guidance for Superfund: Volume 1: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment)* (U.S. EPA 2004), which provides dermal absorption information for only two chemicals, arsenic and cadmium. U.S. EPA (2004) states that there is insufficient information to estimate dermal exposure for other metals. Thus, exposure will be quantified only for metals with EPA dermal absorption factors.

The 1995 offsite risk assessment (Kleinfelder and Hydrometrics 1995) concluded that exposure via uptake of metals (arsenic, cadmium, and lead) in soil through consumption of homegrown vegetables is a lesser pathway of exposure relative to soil ingestion, and is associated with considerable uncertainty. This conclusion has been supported by other EPA risk assessments (e.g., Glass and SAIC 1992; Weston 1996; CDM 1996; U.S. EPA and SRC 2001; SRC 2002). Moreover, growing vegetables at home often involves adding compost and humus, which would dilute soil concentrations of the constituents present, resulting in lower concentrations in garden soils than in other areas of a yard (U.S. EPA and SRC 2001). Biomonitoring data (i.e., blood

lead levels and urinary arsenic levels) have also indicated no increased exposure by residents who have a vegetable garden or consume homegrown produce[3], and that arsenic and lead exposures calculated by risk assessments of soil ingestion overestimate actual exposures in children. Consumption of homegrown vegetables was found to not contribute significantly to risks offsite in East Helena (Kleinfelder and Hydrometrics 1995). Nevertheless, the homegrown vegetable pathway will be addressed by the HHRA for the onsite residential area.

4.2.2 Offsite Resident

Offsite residential exposures were evaluated previously (Kleinfelder and Hydrometrics 1995). However, two exposure pathways that are not fully addressed in that assessment were current exposure to CoPCs in groundwater that has migrated offsite and inhalation of CoPCs in resuspended fugitive dusts originating from onsite.

Use of groundwater from the shallow perched aquifer impacted by site metals as a domestic drinking water source is unlikely because of its slow recharge and low hydraulic yield. The East Helena municipal water supply is out of the study area and not impacted by site CoPCs. Nevertheless, some private wells exist in the offsite residential area that draw from the aquifers that are affected by the site. These wells are currently monitored. Thus, groundwater consumption by offsite residents will be evaluated in the HHRA. Dermal uptake of metals from water, particularly from domestic water use, will also be evaluated in the HHRA, although is likely to be considerably less than by ingestion. For example, a study in Wisconsin (Knobeloch 2002) indicated that residents with high arsenic levels in their well water did not have elevated urinary levels if they drank bottled water, even though they bathed in the well water and used it for washing and other household purposes.

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[3] Sites include Anaconda, Montana (Hwang et al. 1997a); Bingham Creek, Utah (UCDEH 1997a); Butte, Montana (BSBDH and University of Cincinnati 1992); Coeur d'Alene, Idaho (IDHW 1999); East Helena, Montana (CDC 1986); Globe, Colorado (CDH 1994); Jasper County, Missouri (Murgueytio et al. 1998); Leadville, Colorado (UCDEH 1997b); Midvale, Utah (Bornschein et al. 1991); Palmerton, Pennsylvania (Advanced Geoservices et al. 1996); Sandy, Utah (UCDEH 1997c); Tacoma, Washington (Polissar et al. 1990).

Offsite residential exposures to metals in air were evaluated in the 1995 HHRA using a combination of measured and modeled data for the community. The concentrations used in the 1995 HHRA were based on measurements made from July 1987 to June 1988, and August 1992 to January 1993. The smelter was still operating at that time and there was considerably more activity onsite that would result in resuspension of fugitive dusts than under current conditions. Of the metals measured in air, a subset (arsenic, cadmium, and lead) were quantitatively evaluated in the 1995 offsite risk assessment. The highest arsenic risks were at the upper end of EPA's target risk range of 10^{-6} to 10^{-4}. Cadmium risks were less than 10^{-4}, and lead in air contributed minimally to lead exposure and risk of an elevated blood lead level. Because air concentrations would be lower now than when the plant was operating, the 1995 HHRA is considered to overestimate current risks. Offsite air exposures will be evaluated in the HHRA using more recent air monitoring data and modeled air concentrations in resuspended dust from soil.

4.2.3 Industrial Worker

Under both current and future use, industrial workers in the facility area could be exposed to site CoPCs through direct contact with site soil (ingestion, inhalation, and dermal contact) and sediment (ingestion and dermal contact) and incidental contact with surface water (ingestion and dermal contact). It is also possible that workers could occasionally contact surface water or catch and consume fish, primarily from Upper Lake.

4.2.4 Recreational User/Trespasser

The facility site is currently fenced and undergoing demolition of smelter structures, and unauthorized access is forbidden. Nevertheless, trespassers may occasionally enter the site to engage in recreation (e.g., fishing), vandalism, or other activities. Under possible future use scenarios, portions of the site could be opened for recreational use, such as hunting, fishing, hiking, bird watching, or swimming. Those engaging in such activities are most likely to be older children and adults rather than young children, who would be more closely supervised and not allowed to travel great distances on a regular basis. The

large area and relative isolation of much of the site would also prevent frequent access by young children.

For young children who are brought to the site if it becomes a recreational area, the occupational exposure scenario is likely to be protective of such recreational exposures because of the more frequent exposure assumed for workers (i.e., 250 days per year). This difference will be addressed quantitatively in the uncertainty section of the risk assessment. Areas that might be used frequently by young children in the future would have exposures similar to public parks in the offsite residential area, and will need to meet similar cleanup levels for these areas.

Current trespassers or future recreational users and trespassers could potentially be exposed to site CoPCs through direct contact with site soil (ingestion, inhalation, and dermal contact) and sediment (ingestion and dermal contact), incidental contact with surface water (ingestion and dermal contact), and consumption of fish from Upper Lake or Prickly Pear Creek.

Trespassers or recreational users could potentially swim on occasion in Upper Lake. Therefore, exposure to surface water through incidental ingestion and dermal absorption will also be evaluated, although dermal absorption from water is expected to contribute only minimally to this pathway.

4.2.5 Rancher

Under current conditions ranchers graze their cattle near the site, but not in the study area. In the future, the facility area could potentially be capped and ranchers may graze cattle on areas close to, but likely not directly on, the former facility area. Although exposure to site CoPCs is possible, significant direct exposures are unlikely to occur because 1) a rancher would spend very little time at the site, 2) only a portion of that time would be out on the more contaminated areas, and 3) to allow sufficient grass for grazing, the soil in the facility area would need to be extensively amended and likely capped, thereby limiting access and exposure to the concentrations present in the facility area. Further, because the types of exposures potentially experienced by a rancher

would be similar to those of an industrial worker, but of less frequency and magnitude, the industrial worker risk assessment will also be protective of a future rancher. Exposure for ranchers will be evaluated in the HHRA through comparison of a rancher's potential exposure with recreational users and onsite workers (e.g., exposure frequency and duration).

The one exposure pathway unique to the rancher scenario is consumption of beef from cattle that have grazed onsite and potentially consumed CoPCs in site grass and soil. As noted above, exposures to metals concentrations in the facility area would be limited and grazing of cattle would require an area larger than the facility area. Metals concentrations in locally grazed beef were evaluated in the 1995 HHRA and no differences were found compared to reference herds. Indirect exposure through beef consumption will be evaluated in this HHRA by evaluating whether exposure conditions for cattle would be significantly different in the future compared to the conditions described in the 1995 HHRA.

5 Human Health Risk Assessment

The East Helena Smelter HHRA will estimate the likelihood and magnitude of risks to potential human receptors posed by current or future exposure to chemicals in soil, sediments, surface water, groundwater, and biota, as a result of former plant operations. This risk assessment is being conducted as part of the Phase II RFI, and will address chemicals at the site and in specific offsite areas that are otherwise not being addressed under the CERCLA offsite investigations. The purpose of the HHRA will be to support risk management decisions on corrective measures that are needed to address potential human health risks.

5.1 Exposure Point Concentrations

EPA guidance (U.S. EPA 1989, 1992, 2002) indicates that exposure point concentrations (EPCs) used in risk assessment calculations should be either the 95%UCL on the mean concentration or the maximum site concentration, whichever is lower. EPA recommends the 95%UCL as an estimate of mean exposure concentration because of the uncertainty associated with estimating the true average exposure concentration at a site. Typically, the lesser of the 95%UCL or the maximum detected concentration is used as the EPC. The 95% UCLs will be calculated in accordance with EPA guidance (Singh and Singh 2007; ProUCL 4.0. 2007; U.S. EPA 2007b) using EPA's ProUCL software. ProUCL provides several methods for dealing with censored data (i.e., undetected values). For data sets with greater than 10–15 samples, one of several parametric or non-parametric computational methods will be used to calculate the 95%UCL based on goodness of fit and other tests performed using ProUCL. Current EPA guidance recommends against replacing undetected values with one-half the detection limit when calculating 95%UCLs or other summary statistics (U.S. EPA 2007b). The effect of undetected values with unusually high detection limits, however, will be considered.

For the onsite residential area, separate exposure point concentrations will be derived for each property, consistent with the assessment of residential properties offsite.

EPCs for lead will be calculated using arithmetic means. As described in model guidance (U.S. EPA 1994b, 1996b), the IEUBK and adult lead model are designed to be applied using average values as input. A geometric standard deviation (GSD) for blood lead values in the general population is then applied to account for variability. EPCs for applicable media will be calculated for individual exposure units in the risk assessment.

When historical data are likely to represent current conditions, those data will be used in the HHRA. Specifically, historical soil and sediment metals data collected in areas that have not been remediated or significantly altered will be used. However, because surface water and groundwater conditions change over time, only the most recent water data will be used in the risk assessment. Qualified data from historical data sets will be included, provided it meets current quality control/quality assurance (QC/QA) criteria.

5.2 Exposure Assessment

The exposure assessment will be conducted using standard EPA methods (U.S. EPA 1989, 1991, 1994b, 1996b, 2003). The following sections discuss the exposure assumptions that will be used in the HHRA, focusing on site-specific modifications to the default assumptions. The exposure assumptions that will be used in the East Helena HHRA are summarized in Tables 8 (soil and sediment), 9 (surface water), 10 (groundwater) and 11 (homegrown vegetables).

Exposure input assumptions for lead are presented separately from those for other metals because of the different risk assessment models required to assess lead. Among the input assumptions in arsenic risk assessments, EPA Region 8 has used site-specific values for bioavailability of arsenic in soil and the ratio of the arsenic concentration in house dust relative to that in soil. The trespasser/recreational user and rancher scenarios also lack EPA default values, requiring site-specific assumptions for soil ingestion rate and site exposure frequency. The food chain pathways (beef ingestion, homegrown vegetable intake, and fish consumption) will likewise need consideration of appropriate input values given the lack of default values. This HHRA will therefore consider possible site-specific values for these assumptions, as discussed below.

5.2.1 Application of Existing Residential Cleanup Levels for Lead and Arsenic

PRGs of 1,000 ppm for lead and 100 ppm for arsenic in soil identified in the Record of Decision (ROD) for the offsite residential area (U.S. EPA 2009a) will be applied to the onsite residential area. Thus, no additional risk estimates will be developed for lead and arsenic for the onsite residential area. Instead, risks will be evaluated by comparison of exposure concentrations to these PRGs. Justification as noted below will be provided to support these PRGs as protective of health based on current knowledge.

As described in Section 2.8, U.S. EPA (2005a) re-evaluated the cleanup level for lead in residential soil based on the 1995 offsite risk assessment, more recent agency guidance, and additional site-specific data collection regarding the ratio of lead in indoor dust relative to outdoor soil and *in vitro* testing of the relative bioaccessibility of lead in soil. The range of possible cleanup levels from this analysis was 250–3,200 ppm with an average of 1,200 ppm and a geometric mean of 990 ppm. Since the 2005 evaluation, EPA has updated two assumptions in the IEUBK child lead model that would increase the model predicted PRGs[4]. First, the default maternal blood lead level has been decreased from 2.5 to 1.0 μg/dL based on an analysis of blood lead concentration data for women of child-bearing age (17–45 years) from NHANES 1999-2004. Second, the default dietary lead intake has been decreased by 25-30 percent for each age group. The combination of these two changes results in a higher PRG than the 2005 re-evaluation. Thus, the lead PRG of 1,000 ppm would still be protective even with changes in the model.

The 1,000 ppm cleanup level for lead is also supported by evidence from monitoring of blood lead levels in the community over time, as described in the ROD (U.S. EPA 2009a). Most notably, as observed earlier in the evaluation of the 1991 blood lead data (Kleinfelder and Hydrometrics 1995), U.S. EPA (2009a) in their review of more recent data noted that paired, co-located soil lead and blood lead data show no measurable relationship when soil lead concentrations are less than 1,000 to 1,500 ppm, including when data are grouped by remediated versus unremediated status. EPA stated,"...unless soil lead concentrations are greater than

[4] U.S. EPA. 2009. Overview of Changes From IEUBKwin version 1 build 264 to IEUBKwin version 1.1.

1,000 to 1,500 ppm, their contribution to blood lead levels is too small to be detected." Although the ongoing blood lead level monitoring in the community by LCCCHD has not in recent years been conducted as a comprehensive study, the levels indicate declines over the past years to near national levels, with few children having blood lead levels above 10 μg/dL, and the vast majority below 5 μg/dL (Table 1). In addition, although the data presented in Table 1 summarize all blood lead tests, and may include data from the same individual, children who are likely to be targeted and encouraged to be sampled are those with risk factors for an elevated blood lead level such as those who live in an older home, live closer to the site, have siblings with elevated blood lead levels, or have had a previously elevated blood lead level.

As described in Section 2.8, EPA calculated a PRG for arsenic in residential soil that was 176 ppm based on the 1995 risk assessment, and revised assumptions for the ratio of arsenic in indoor dust to outdoor soil (from 1 to 0.5) and oral bioavailability of arsenic in soil (from the default of 0.8 to 0.5) (Hammon 1999; Brattin 1999; Hammon and Brattin 2001; U.S. EPA 2007a). EPA subsequently selected an arsenic cleanup level of 100 ppm as a risk management decision (U.S. EPA 2009a). Two points ensure that application of this cleanup level will be health protective. First, it is significantly less than the calculated PRG of 176 ppm. Second, the oral bioavailability factor used in U.S. EPA (2007a) likely overestimates arsenic bioavailability in East Helena soil. As discussed in the subsequent section, an arsenic oral bioavailability factor of 0.43 will be applied in the HHRA.

As noted by U.S. EPA (2009a),

> Cleanup levels for lead and arsenic in soil at this Site have been shown to be protective and are well within ranges of acceptability. For lead, EPA's National Lead Sites Consultation Group requires special consultation if the proposed cleanup action for lead in residential soil is outside the range of 400 to 1,200 ppm. For arsenic, the residential cleanup action level is within EPA's generally accepted risk range for excess cancer risks (risk of one excess cancer for every 10,000 to 100,000 individuals exposed) and is within the acceptable range of residential cleanup levels for arsenic in Region 8 (generally 70 to 240 ppm).

5.2.2 Soil

The soil ingestion, dermal contact, and particulate inhalation pathways will be evaluated for onsite residents, industrial workers, rancher, and recreational users/trespassers. As summarized in Table 8, U.S. EPA default inputs and algorithms for reasonable maximum exposure will be applied for all assumptions with the exception of arsenic bioavailability, indoor dust concentrations, and specifically for the recreational user/trespasser, soil ingestion and exposure frequency. These modifications are discussed below. In addition, some chemical-specific aspects of the dermal assessment and the approach identified in the U.S. EPA (2009c) inhalation guidance are further described within this section.

5.2.2.1 Recreational/Trespasser/Rancher Soil Ingestion Rate

U.S. EPA calculated risks and a PRG for a recreational scenario in the offsite community assuming a relatively high ingestion rate of soil (100 mg/day), which is the same as in the default residential scenario for an older child or adult (Brattin 2007). This residential soil ingestion rate is the sum of indoor dust (55 percent) and outdoor soil (45 percent). Thus, an estimate of 100 mg/day from the site during recreation is higher than for outdoor soil under the residential scenario. The ingestion rate to be used in the HHRA for the trespasser, recreational user, or rancher will be 45 percent of the default soil and interior dust ingestion rate, or 45 mg/day for each visit to the site.

5.2.2.2 Recreational/Trespasser/Rancher Exposure Frequency

An exposure frequency that is specific to trespassers or recreational users of the site will be applied to ingestion, dermal contact, and inhalation pathways. To identify a representative exposure frequency for this site, risk assessments conducted for similar sites were reviewed to provide a basis. The most applicable comparison is EPA's baseline HHRA for the Anaconda smelter site (CDM 1996). The Anaconda risk assessment included two recreational exposure scenarios, a recreational swimming scenario and a dirt biker scenario. For the swimming scenario it was noted that based on the climate of southwestern Montana, exposure to surface water was likely only 5 months of the year. During that time, visitors were assumed to swim

and play in the water 2 times per week, resulting in an exposure frequency of 40 days per year. The exposure frequency for the mountain biker scenario was 26 days per year.

Brattin (2007) assumed site exposure frequencies of 150 days/year for arsenic for offsite recreational areas within the East Helena community. No basis was provided for these assumptions. Recreational visits to a park within the offsite residential area would likely be more frequent than visits to the large area of the site, although it does depend on future land uses. Based on the extensive weather data that are available for Helena for 1971–2000, 132 days per year, or 19 weeks, on average have no snowfall.[5] Assuming that visits involving soil ingestion at the site would occur on snow-free (i.e., warmer) days or weeks, and that a conservative frequency of visits is 5 of 7 snow-free days, yields an estimate of 95 days/year. Rounding up, a recreational exposure frequency of 100 days/year will be assumed. This exposure frequency (a visit to the site involving soil exposure every 3 to 4 days on average over the year) is assumed to be protective of site exposure for the rancher. A rancher with more regular exposure at the site would be more similar to the worker exposure scenario.

5.2.2.3 Bioavailability of Metals in Soil

The bioavailability of arsenic in soil relative to soluble arsenic in water must be considered in assessing risks of arsenic in soil because the toxicity criteria for calculating cancer and noncancer risks are based on populations that drank elevated concentrations of arsenic in well water. EPA's default relative bioavailability for arsenic in soil is 80 percent (SRC 2002). However, EPA Region 8 has set a bioavailability factor sites (e.g., 40 percent for Kennecott Utah Copper site) that is less than their default bioavailability, based on studies at multiple mining sites (CDM 1999). Brattin (2007) specified a relative bioavailability factor for arsenic in East Helena residential soil of 50 percent. This value will be used for soil on the plant site as well.

A relative bioavailability factor of 50 percent is among the higher factors found for sites based on bioavailability studies. *In vivo* (animal feeding studies) and *in vitro* (extraction tests)

[5] http://nowdata.rcc-acis.org/TFX/pubACIS_results

bioavailability testing results for arsenic in soil from various sites indicate ranges of approximately <3 to 62 percent with few that exceed 50 percent (Ruby et al. 1999; Rodriguez et al. 1999; Roberts et al. 2002; 2007). Relative bioavailability of arsenic in soils at the Murray Smelter site in Utah was 26 percent (Weston 1997), which is similar to soils (18 percent) and dust (25.8 percent) at the Anaconda Smelter site in Montana (CDM 1996). The assumption of 50 percent should thus be adequately protective for the East Helena plant site.

For the rail car and slag (if slag is included in the assessment) areas of the East Helena site, however, we propose to conduct *in vitro* bioaccessibility and soil mineralogy studies to support derivation of a site-specific arsenic relative bioavailability factor (U.S. EPA Region 8, 2005; U.S. EPA 2007c). The form of arsenic-containing material in these areas is likely to differ from that in soil on the plant site.

Because of the lack of information on the bioavailability of other metals in soil, we do not propose to derive site-specific bioavailability factors for other metals (except lead, see below).

5.2.2.4 Indoor House Dust Concentration

The soil ingestion rate for children and adults includes all material of soil origin both outdoors and in the home. Measurements at several sites indicate that arsenic concentrations in house dust are lower than in soil, particularly for sites with no active air emissions source. EPA Region 8 has used the following equations for calculating house dust arsenic based on soil and house dust data at different sites:

1. Conc. Dust (ppm) = (Conc. Soil × 0.43) + 18 (Anaconda Smelter, Montana; CDM 1996)
2. Conc. Dust (ppm) = (Conc. Soil × 0.06) + 11 (Denver, Colorado; U.S. EPA and SRC 2001)
3. Conc. Dust (ppm) = (Conc. Soil × 0.20) + 10 (Murray, Utah; Weston 1997)
4. Conc. Dust (ppm) = (Conc. Soil x 0.20) + 23 (Midvale, Utah; Griffin 2006)
5. ln [Conc. Entryway Dust (ppm)] = 0.161 × ln [Conc. Soil] + 0.617 (Bingham Creek, Utah; UCDEH 1997a).

The Anaconda residential community is near a former copper smelter that had high air emissions of arsenic while the smelter was operating. Those emissions resulted in greatly elevated environmental levels of arsenic throughout the surrounding area. This resulted in the more conservative house dust to soil transfer factor for the Anaconda Smelter site. Site data from East Helena for lead indicated an indoor dust to soil concentration ratio of 0.17 for lead. Lead is expected to have a higher indoor dust concentration relative to outdoor soil than other metals, as a result of interior contributions of lead from lead-based paint. However, based on the recommendation of EPA Region 8, because of uncertainties in these data for arsenic and other metals, this assessment will apply the relatively conservative relationship of 0.43 from Anaconda for East Helena. As recommended by U.S. EPA Region 8 (1994a) for calculating cleanup goals for soil, the slope of the relationship (the transfer factor) between house dust and soil concentrations (i.e., 0.43) is used without the intercept, which represents contributions from non-yard sources.

Although similar data are not available for most metals, the same transfer factor would be expected to be applicable. Therefore, the relationship derived using arsenic data will also be applied to other site CoPCs.

5.2.2.5 Dermal Contact With CoPCs in Soil

As described above, the EPA dermal risk guidance (U.S. EPA 2004) provides dermal absorption information only for arsenic and cadmium, with estimates of dermal absorption of 3 percent and 0.1 percent, respectively. These values are based on studies by Wester et al. (1992, 1993) in which metals were held in place on the skin of monkeys for 24 hours. The basis of the 3 percent absorption (Wester et al. 1993) has been updated more recently by research conducted by the same laboratory (Lowney et al. 2007), which indicates that arsenic absorption from soil is less than 1 percent, and undetectable. Dermal absorption will be evaluated as part of an uncertainty assessment for those metals (arsenic and cadmium) that have recommended absorption factors. The effect of using a 1 percent rather than a 3 percent absorption factor for arsenic will also be assessed.

5.2.2.6 Inhalation of Particulates from Soil

The recent EPA guidance document for inhalation, entitled *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment)* (U.S. EPA 2009c), will be used as basis for the exposure estimates for inhalation. As indicated in that guidance, exposure estimates are derived for direct comparison with unit risks or reference concentrations and, as such, incorporate exposure to all ages and do not require site-specific assumptions about inhalation rates. Exposure estimates for inhalation will be derived only for chemicals that have unit risk or reference concentration values available for analysis of inhalation toxicity. Exposure times per day, identified by U.S. EPA (2009c) in their examples have been proposed for use here including the following times: a residential exposure time of 24 hours; an occupational exposure time of 8 hours and a recreational exposure time of 2 hours. Exposure point concentrations for air will be derived from site soil concentrations through application of a particulate emission factor of 1.32×10^9 as described in U.S. EPA (1996a).

5.2.3 Surface Water

Incidental exposure to metals in surface water through ingestion and dermal contact will be evaluated for trespassers, under current conditions, and for recreational users/trespassers under future site use. Although trespassers under current conditions are likely to have less frequent contact with site CoPCs for shorter durations, the HHRA will conservatively assume the same exposure as for recreational users under a future scenario where access is permissible. As summarized in Table 9, the assumptions that will be used to estimate exposure for this scenario are similar to the groundwater exposure pathway, but with modifications to account for less exposure.

In EPA's analysis, the amount of actual exposure from incidental surface water ingestion, averaged over a lifetime, would be negligible (U.S. EPA 2000). However, acknowledging that some states already have established guidance based on incidental ingestion, EPA provides limited guidance in the technical support document to the human health methodology for Ambient Water Quality Criteria (U.S. EPA 1998). EPA's recommendation is based on an

assumption that a person incidentally swallows 30 mL (0.03 L/day) of water per hour while swimming or playing in the water and spends an average of 1 hour in the water per swimming event (i.e., per day). Based on this guidance, an incidental surface water ingestion rate of 0.03 L/hour and an exposure time of 1 hour/day will be used in the East Helena HHRA. These values will be used in conjunction with the exposure frequency for the trespasser/recreational visitor scenario of 100 days per year (discussed in the soil exposure section).

Dermal uptake from metals concentrations in water or soil is typically low. Recognizing this, U.S. EPA (2004) Appendix B estimates the relative importance of the dermal pathway in risk assessment for metals in water and identifies the following chemicals for quantification of dermal exposure in water based on a estimated contribution from the dermal pathway of at least 10 percent of the oral pathway: beryllium, cadmium, chromium (III and VI), and vanadium. Based on current screening data, only cadmium and vanadium would be further evaluated for this pathway. However, if additional metals are identified as CoPCs they may also be considered for the dermal pathway. The dermal surface areas for swimming are default values for bathing identified by U.S. EPA (2004) and the dermal surface areas for wading represent 25 percent of the surface area of the body. These were selected considering that the surface areas for residential exposures, which include assumed exposure of the head, forearms, and lower legs, represent 50 percent of the surface area of the body. Estimates for wading were assumed to not include exposure of the head.

As noted above for dermal absorption of metals from soil, this pathway will be evaluated as part of an uncertainty assessment for the metals that are recommended by EPA guidance for assessment by this route.

5.2.4 Groundwater

Exposure to metals in groundwater will be evaluated for offsite residents. The exposure assumptions that will be used are all standard EPA defaults and are summarized in Table 10. This approach is consistent with U.S. EPA (1989) risk assessment guidance and with the agency's approach for calculating MCLs to assess risks from drinking water for the residential

scenario. The input assumptions used for drinking water intake and body weight represent lifetime exposure including all ages. Early childhood exposure can be assessed in the uncertainty section by comparison to EPA 1-day or 7-day health advisories for metals that have these values. Exposure to arsenic in water will be assessed by direct comparison of arsenic water concentrations to the MCL, for consistency with the approach currently being used to evaluate and communicate risks to residents in the community from well water exposures. Exposure for metals from water via dermal absorption will be evaluated in the uncertainty section for the metals described above for dermal contact with surface water.

5.2.5 Food Chain

Indirect exposure to metals in soil may be possible for onsite residents consuming homegrown vegetables, or for a rancher ingesting beef raised at the site. Indirect exposure to metals in water and sediment may also occur for recreational anglers who consume fish from site-related water bodies. Independent of elevated levels from the site, metals are present in all foods because of natural occurrence in soil and water. Therefore, assessment of these pathways should consider incremental exposures from the site over background levels of metals in vegetables, fish, or beef. If such incremental exposures are not considered, the calculations will assume that exposed individuals are eating homegrown vegetables, beef, or fish from the site in addition to a complete normal diet. Site-related foods, however, likely replace other foods in the diet that contain background levels of metals from other sources. Incremental exposures can be considered by estimating uptake of metals in excess of background or by subtraction of background levels in foods reported in published sources (e.g., USDA).

5.2.5.1 Beef Consumption

As described previously, consumption of beef from locally grazed cattle is a potentially complete exposure pathway that has been evaluated previously for this site (Kleinfelder and Hydrometrics 1995) and has considerable associated uncertainty. The 1995 HHRA found no differences in metals concentrations (i.e., cadmium) in locally grazed beef compared to reference herds. Indirect exposure through beef consumption will be

evaluated in this HHRA by evaluating whether exposure conditions for cattle would be significantly different in the future compared to the conditions described in the 1995 HHRA. This HHRA will also evaluate whether metals other than cadmium, arsenic, or lead may also be a concern in cattle.

5.2.5.2 Homegrown vegetable consumption

As was beef consumption, consumption of homegrown vegetables was also evaluated by the 1995 assessment, and the reported arsenic risk estimate for vegetable consumption was 17-fold lower than that for soil ingestion. Nevertheless, to evaluate current residential risks from soil-related sources, this pathway will be addressed for the onsite residential area. Specifically, the HHRA will describe whether the homegrown produce assessment conducted by the 1995 offsite risk assessment is still protective of health. This evaluation will assess whether the offsite residential PRGs that will be used to assess onsite residential exposures to lead and arsenic are also protective of the homegrown vegetable pathway. The previous 1995 homegrown produce assessment for cadmium can likewise be assessed based on more current information.

For other metals, uptake factors can be derived using the same analysis as the 1995 risk assessment (Glass and SAIC 1992). This study, prepared for EPA Region 10, conducted a detailed statistical analysis of multiple types of vegetables grown in a range of soil concentrations in a number of residential yards located near a smelter site in Ruston/Tacoma, Washington. For each metal sampled, this study reported separate equations for calculating vegetable uptake rates depending on the type of vegetable (root or leafy) and, in some cases, concentration of the metal in soil. Leafy and root vegetables were found to have greater uptake of metals from soil than other vegetable types, such as reproductive or storage organs (e.g., tomatoes, zucchini, beans, potatoes). Review of the literature since 1995 indicates that this study still has the most comprehensive evaluation of uptake factors of metals in residential soil near a smelter site. As noted by the 1995 risk assessment, Western Washington soils tend to be more acidic than Helena soils and thus metals in soil should be more mobile for uptake by

plants. These conditions should thus make these data tend to overestimate vegetable uptake of metals in East Helena.

To evaluate the vegetable consumption rates used in the 1995 HHRA, more recent summaries of consumption rates of homegrown vegetables will be considered (U.S. EPA 1997). U.S. EPA (1997) summarizes short-term (i.e., one week consumption) survey data for various parts of the U.S. for consumption of homegrown produce. We propose to use rates for consumers only, not per capita, because the latter includes non-consumers on the survey days. Consumption rates are reported for root vegetables but not for leafy vegetables. Rates for "exposed" vegetables will be used to represent leafy vegetables, although these consumption rates include fruiting parts of vegetables, which have low accumulation of metals. Because these rates may overestimate consumption for long-term consumption, we propose to use 75th percentile intake rates for the western U.S. rather than the 90th or 95th percentile. U.S. EPA (1997) recommends that these consumption rates, which are based on weight of vegetables as initially obtained from the garden, be adjusted for loss of weight during preparation. Accordingly, the amount of preparation loss reported by U.S. EPA (1997) will be averaged over applicable root or leafy vegetable types (see Table 11). Data for storage organs like potatoes will not be included.

Because sufficient data are not available to derive vegetable uptake factors for East Helena, this pathway is likely associated with considerable uncertainty. Data are also unavailable on local homegrown vegetable consumption rates, therefore requiring the use of summary statistics from national surveys. This evaluation is thus considered more of a semi-quantitative screening to assess the potential contribution of this pathway.

5.2.5.3 Fish Consumption

Potential exposures by consumption of fish can first be evaluated by comparison of surface water metals concentrations to ambient water quality criteria for consumption of fish for metals with such criteria. The fish consumption pathway will also be evaluated using the additional data collected regarding fish tissue concentrations in the relevant water bodies onsite.

Specifically, exposure will be assessed using the edible muscle tissue concentrations and an assumed fish tissue consumption rate. Exponent will work with EPA and the Montana agencies to identify appropriate fish consumption rates for local anglers. If no such appropriate values are available, the assessment can rely on national summary data, such as a 25 g/day consumption rate recommended by U.S. EPA (1997) for recreational anglers, based on data for the Great Lakes and for lakes and streams in Maine. Such intake assumptions are based on fishermen who are not restricted to a particular area. Therefore, to represent the relatively smaller area and lower level of available fishery resource related to the site, the planned evaluation of fish consumption will also apply a fractional intake of 0.33 that assumes anglers would obtain fish only from the site water bodies for a third of their recreational angling.

5.2.6 Lead Risk Assessment

Unlike other chemicals, lead exposure is evaluated by estimating its effect on increasing blood lead levels rather than by calculating a daily dose per body weight. EPA has developed two models for assessing lead exposure: the IEUBK model for a young child (U.S. EPA 1994b) and a simplified linear model for exposure to adults (EPA adult lead model; U.S. EPA 1996b). Both models predict steady-state chronic blood lead levels assuming relatively frequent exposure over approximately a year. The child model is typically used to assess residential exposure and the adult model is used to assess exposure to workers or in other scenarios involving adults or older children.

The PRG of 1,000 ppm for lead in soil identified in the ROD for the offsite residential area (U.S. EPA 2009a) will be applied to the onsite residential area. Therefore, the EPA child lead model calculations will not be performed for this area.

Under commercial or industrial land use conditions, those with the greatest exposure are adults rather than young children. Trespasser, recreational, and rancher exposures to the site will also most likely involve older children and adults. The fetus of a pregnant woman is therefore considered to be the most sensitive receptor for lead exposure and toxicity under these scenarios. The EPA adult lead model (U.S. EPA 1996b) estimates an average blood lead level

for the fetus of a pregnant woman based on additional exposure (above a baseline level) to lead in soil. An appropriate GSD is then applied to estimate upper percentile blood lead levels. Model input assumptions should thus be central tendency estimates.

Site-specific modifications to the EPA default assumptions for an occupational scenario (U.S. EPA 1996b) are described below. Model inputs are summarized in Table 12.

5.2.6.1 Baseline Blood Lead Level and GSD

Since EPA's evaluation of the use of the adult lead model to develop occupational and recreational PRG's for the offsite area (Brattin 2007), the EPA default guidance has updated assumptions for the baseline blood lead level (Pb0) and the GSD, based on the latest available results from national survey data (1999–2004) (U.S. EPA 2009d). With the decline in national blood lead levels over time, the new default value for Pb0 is 1.0 μg/dL instead of 1.7 to 2.2 μg/dL (1.7 was used by Brattin 2007). Therefore, a Pb0 of 1.0 μg/dL will be used in this model.

U.S. EPA (2009d) recommends a new default GSD value of 1.8 instead of a range of 1.8 to 2.1 (1.8 was used by Brattin 2007). Nevertheless, the appropriate measure to use in the adult lead model is the inter-individual GSD, not a population GSD. U.S. EPA Region 8 has recommended an inter-individual GSD for pregnant women of 1.49 based on an analysis of blood lead data of pregnant and nursing women collected in a 1996 study of blood lead data from two Salt Lake Valley sites in Utah (Walker 1996). Walker (1996) also reported the range in population GSDs as 1.53 to 1.69; however, these values are inappropriate to use in the model because they also include population level variation in blood lead from variation in lead concentrations in soil and dust throughout the site. An inter-individual GSD value similar to that recommended by Walker (1996) has been used in other U.S. EPA Region 8 risk assessments (e.g., URS 2001; SRC 2003). Limited blood lead data for pregnant women from the East Helena site are available from 1991, but at that time, national blood lead levels were higher and the smelter was still operating. Therefore, we propose to use a baseline blood lead level a GSD of 1.5 as representative of women in the Rocky Mountain Region.

5.2.6.2 Indoor Dust Concentration

The EPA adult lead model (U.S. EPA 1996b) recommends a default dust lead concentration equal to the soil lead concentration. However, in residential risk assessments, the EPA default ratio for the concentration of lead in indoor dust relative to outdoor soil (0.70 under the multiple source analysis function of the IEUBK model) has been replaced with site-specific values for several mining and smelting sites:

1. Conc. Dust (ppm) = (Conc. Soil × 0.15) + 77 (Sandy Smelter, Utah; U.S. EPA 1995b)
2. Conc. Dust (ppm) = (Conc. Soil × 0.25) + 500 (Leadville, Colorado; Weston 1996)
3. Conc. Dust (ppm) = (Conc. Soil × 0.34) + 150 (Denver, Colorado; U.S. EPA and SRC 2001)
4. Conc. Dust (ppm) = (Conc. Soil × 0.35) + 90 (Murray, Utah; Weston 1997)
5. Conc. Dust (ppm) = (Conc. Soil × 0.43) + 90 (Bingham Creek, Utah; Life Systems 1995; U.S. EPA 1995a).

U.S. EPA (2005a) re-evaluated the ratio of lead in indoor dust relative to outdoor soil in East Helena. House dust samples were collected at 30 homes in East Helena, which were selected to be representative of the range of yard soil concentrations and locations in the community. Interior dust lead concentrations and lead loading in dust (i.e., mass of lead per square area) were weakly correlated. House dust lead concentration was related to the lead concentration in yard soil by a slope of 0.17 and an intercept of 271 ($R^2 = 0.0867$). The increase in lead loading with increase in soil concentration was similarly low and poorly correlated. Although the ratio of lead in dust to lead in soil of 0.17 is much lower than the EPA lead model default of 0.7, EPA noted that this low ratio is similar to those observed at other mining and smelting sites in the Rocky Mountain region. A site-specific ratio of lead in dust to lead in soil of 0.17 will therefore be used for the occupational scenario as well. The intercept term will not be used.

5.2.6.3 Gastrointestinal Absorption of Lead

The default soil and dust bioavailability factor for the adult lead model is 12 percent, based on an absolute absorption rate for soluble lead of 20 percent, multiplied by a relative bioavailability of lead in soil compared to soluble lead of 60 percent. For the East Helena HHRA, *in vitro* bioaccessibility and soil mineralogy studies will be conducted for the slag pile area (slag) and the rail car staging area (ore spillage) to support derivation of a site-specific relative lead bioavailability factor to replace the default of 60 percent, if justified (U.S. EPA 2007c). The soil in these areas was affected by materials that are expected to differ geochemically from smelter emissions. The site-specific value will then be multiplied by the absolute absorption rate for soluble lead of 20 percent to calculate a site specific bioavailability factor for the adult lead model. For soil elsewhere on the facility, the default absolute bioavailability assumption in the adult lead model will be used, consistent with the approach used by U.S. EPA (2005a) for off-site residential soil based on their bioaccessibility results.

5.2.6.4 Trespasser/Recreational/Rancher Soil Ingestion Rate

The default adult residential soil ingestion rate of 50 mg/day includes soil and dust ingested both indoors and outdoors with an assumption from the child lead model that 45 percent of exposure occurs outdoors and 55 percent is indoors. For the trespasser and recreational visitor, exposure to soil at the site will be outdoors only. Therefore, it is assumed that these receptors will consume their daily outdoor soil intake (23 mg/day) with each visit to the site.

5.2.6.5 Trespasser/Recreational Exposure Frequency

Brattin (2007) assumed offsite exposure frequencies to lead in soil of 100 days/year for recreational areas within the East Helena community. No basis was provided for these assumptions. Recreational visits to a park within the offsite residential area would likely be more frequent than visits to the large area of the site, although it does depend on future land uses. Based on the extensive weather data that are available for Helena, Montana, for 1971-2000, 132 days per year, or 19 weeks on average, have no snowfall. Assuming that visits involving soil ingestion at the site would occur on snow-free (i.e., warmer) days or weeks and

that a conservative central tendency frequency of visits is 3 of 7 snow-free days, yields 57 days per year. Rounding up, a recreational exposure frequency of 60 days per year will be applied in the HHRA for trespasser or recreational lead exposures. The averaging time in the lead model represents the period of time over which steady state exposure conditions can be approximated. For the trespasser/recreational scenario that is the 132 approximately contiguous snow-free days during which soil exposure is considered to occur.

5.3 Toxicity Assessment

In the toxicity assessment, hazards associated with chemicals of concern at the site are evaluated. For noncarcinogenic chemicals, EPA has developed specific toxicity criteria called oral reference doses (RfDs) and inhalation reference concentrations (RfCs). An RfD or RfC is an estimate of the level of daily exposure that is likely to be without appreciable risk of health effects over a lifetime, even in sensitive populations. EPA has not developed an RfD or RfC for lead, but rather evaluates lead toxicity in reference to blood lead levels. For carcinogenic chemicals, EPA has developed toxicity criteria called carcinogenic slope factors (CSFs). A CSF is an upper bound, approximating a 95% confidence limit on the increased cancer risk from a lifetime exposure to a chemical. CSFs are developed under the assumption that there is no threshold below which exposure would not contribute to cancer. Consequently, cancer risks are not expressed as being above or below a safe level. Rather, they are expressed as whether the predicted excess risks are within an acceptable range. RfDs, RfCs, and CSFs available online in EPA's Integrated Risk Information System[6] will be used in the HHRA.

5.4 Risk Characterization

In risk characterization, quantitative exposure estimates and toxicity factors are combined to calculate numerical estimates of potential health risk. In this section, potential noncancer health risks will be estimated assuming long-term exposure to contaminants detected in site media. The risk characterization methods described in EPA guidance will be applied to calculate

[6] http://www.epa.gov/iris/

potential reasonable maximum estimate (RME) and typical excess lifetime cancer risks for carcinogens and hazard indices for contaminants with noncancer health effects. These methods and the results of the risk characterization are described briefly here, and will be fully discussed in the HHRA when completed.

5.4.1 Risk Estimation

Cancer risk is estimated by multiplying the chronic daily intake of the chemical by its CSF:

$$\text{Risk} = \text{Intake} \times \text{CSF}$$

In risk assessment for carcinogenic chemicals, it is assumed that there is no intake level below which the risk of cancer would not be increased incrementally. Thus, cancer risks are expressed as the increase in probability that an individual could contract cancer in his or her lifetime as a result of exposure to site-related chemicals. A 1×10^{-5} cancer risk, for example, represents a one-in-one-hundred-thousand additional probability that an individual may develop cancer over a 70-year lifetime as a result of the exposure conditions evaluated. The likelihood that actual risks are greater than estimated risks is very low because of the conservative assumptions used to develop cancer risk estimates; in fact, actual risks may be significantly less than predicted values. EPA's Guidelines for Cancer Risk Assessment states, "...the linearized multistage procedure (typically used to calculate CSFs) leads to a plausible upper limit to the risk that is consistent with proposed mechanisms of carcinogenesis....The true value of the risk is unknown, and may be as low as zero" (51 Fed. Reg. 185:33992, 33998). EPA guidance indicates that predicted risks in the range of 1×10^{-6} to 1×10^{-4} are considered acceptable.

With the exception of lead, risks associated with exposure to noncarcinogenic chemicals are evaluated by comparing estimated intake levels with RfDs, and calculating a hazard quotient:

$$\text{Hazard Quotient} = \frac{\text{Intake}}{\text{RfD}}$$

A hazard quotient less than 1 implies that exposure is below the level that is expected to result in a significant health risk. A hazard quotient greater than 1 does not necessarily mean that an effect would occur, rather that exposure may exceed a general level of concern for potential health effects in sensitive populations.

Risks associated with exposure to lead in each receptor population are expressed in two ways:

1. The predicted geometric mean of blood lead is compared to the EPA target blood lead level of 10 μg/dL
2. The predicted probability of exceeding the target blood lead level is compared to the target probability of 5 percent.

Values less than the target levels imply that exposure is below the level that is expected to result in a significant health risk. Values greater than the target levels do not necessarily mean that an effect would occur, rather that exposure may exceed a general level of concern for potential health effects in sensitive populations.

5.4.2 Uncertainty Analysis

Risk assessment is subject to a number of uncertainties. General sources of uncertainty include the site characterization (adequacy of the sampling plan and quality of the analytical data), the exposure assumptions, estimation of chemical toxicity, background concentrations, and the present state of the science involved. Major sources of uncertainty and their effects on risk characterization conclusions will be discussed in detail in the uncertainty analysis and, where possible, addressed by conducting additional analyses. In particular, the potential additional contribution of exposure from dermal absorption and homegrown vegetable consumption will be evaluated quantitatively for metals with available information to permit this assessment.

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Figures

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EAST HELENA
AMERICAN CHEMET
ASARCO FACILITY
ASARCO HOUSING
VOLLMER RESIDENCE
UPPER LAKE
LOWER LAKE
UPPER LAKE MARSH
CAMU PHASE I CELL
CAMU PHASE II CELL
HIGHWAY 12
PRICKLY PEAR CREEK
WILSON IRRIGATION DITCH OPEN CHANNEL
WILSON IRRIGATION DITCH BURIED PIPE
SKELTER ROAD
CONTINUES ~0.5 MILES UPSTREAM

NORTH

SCALE
0 (In Feet) 700

LEGEND

- FACILITY BOUNDARY STUDY AREA
- GROUNDWATER STUDY AREA (EXTENTS UNKNOWN WILL BE BASED ON FUTURE GW INVESTIGATIONS)
- SURFACE WATER STUDY AREA
- SURFACE SOIL STUDY AREA
- MARSH STUDY AREA

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HUMAN HEALTH RISK ASSESSMENT WORK PLAN

SITE LOCATION MAP

FIGURE
1

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April 2004 aerial photograph obtained from Montana NRIS (http://nris.mt.gov/nsdi/orthophotos/2004_helena.asp)

HUMAN HEALTH RISK ASSESSMENT WORK PLAN	**PHASE I AND PHASE II RFI SURFACE SOIL SAMPLING LOCATIONS ASARCO EAST HELENA FACILITY**	**FIGURE 2**

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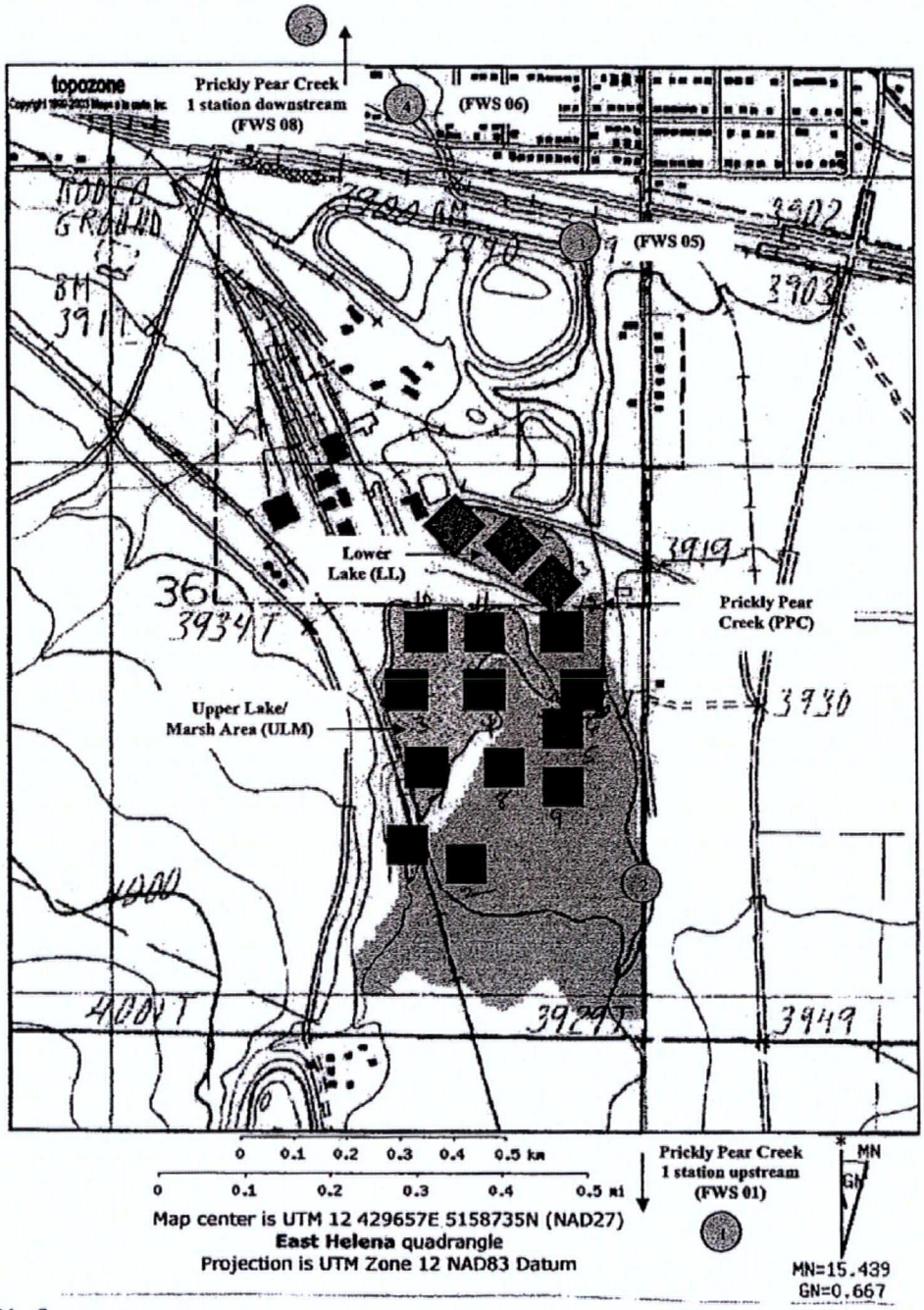
Figure 3-1 (Part A)
Sampling Locations for the Fall 2003 Ecological Field Investigation

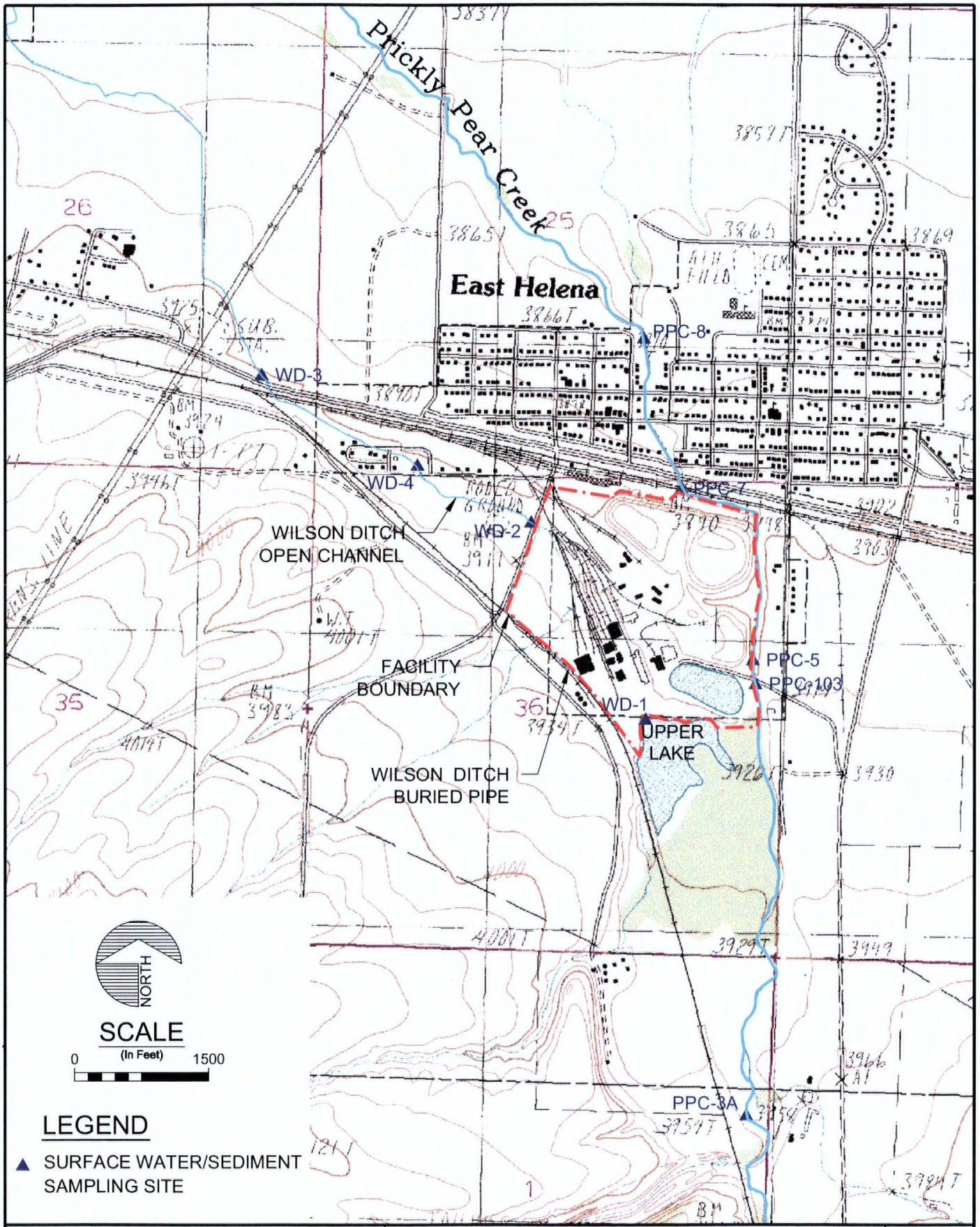


Map Source: www.topozone.com
Prickly Pear Creek stations are also identified with their corresponding USFWS (1997) sampling location #

■ = Upper Lake/ Marsh Area (ULM) ◆ = Lower Lake (LL) ◎ = Prickly Pear Creek (PPC)
[symbols outlined in red indicate sediment toxicity tests were conducted for this location]

Source: U.S. EPA (2005b)

Figure 3. Surface water and sediment sampling locations for the Supplemental Ecological Risk Assessment.



HUMAN HEALTH RISK ASSESSMENT WORK PLAN	**PRICKLY PEAR CREEK SURFACE WATER MONITORING STATIONS**	FIGURE **4**

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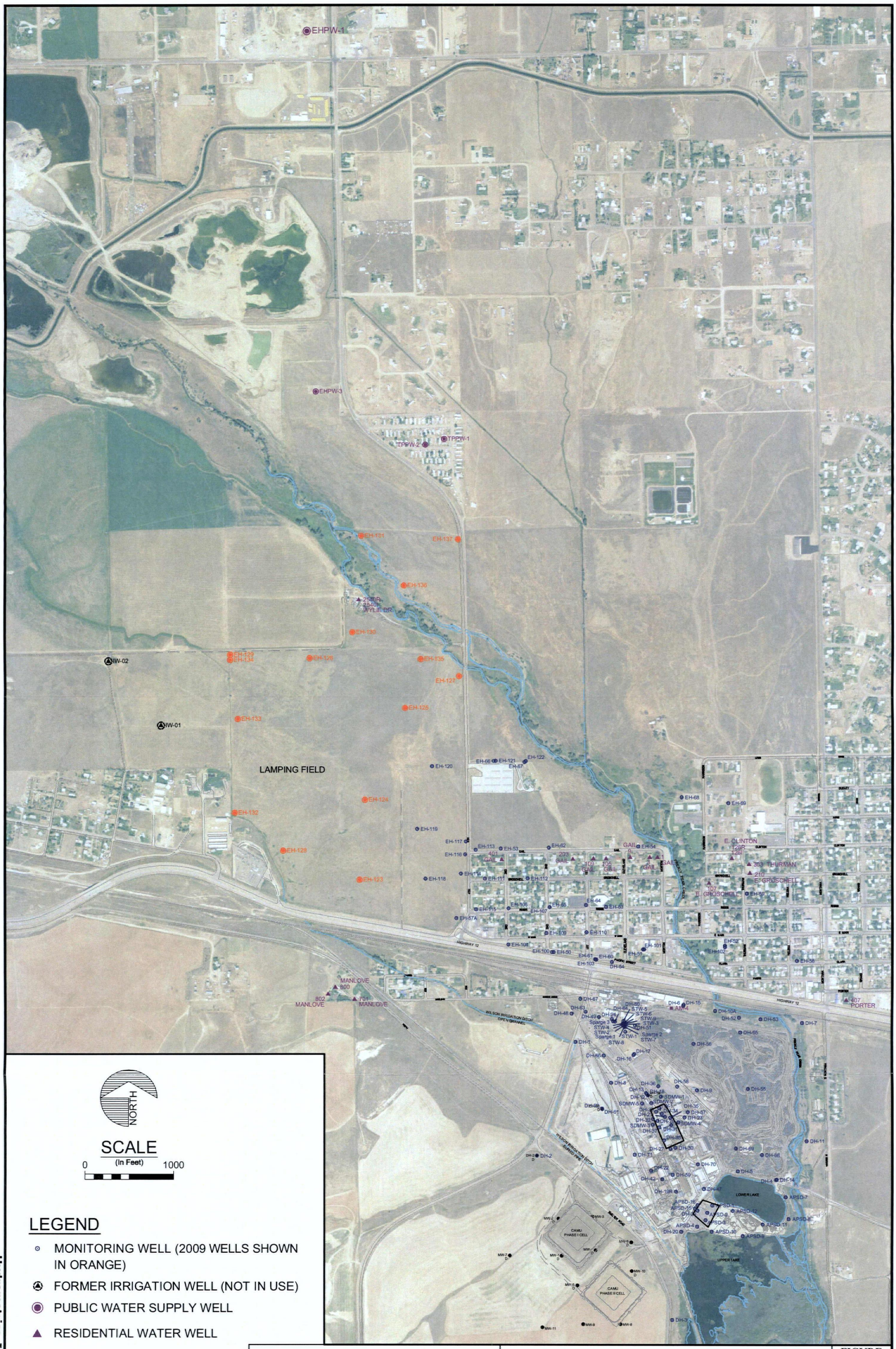

NORTH

SCALE
(In Feet)
0 1000

LEGEND

- MONITORING WELL (2009 WELLS SHOWN IN ORANGE)
- FORMER IRRIGATION WELL (NOT IN USE)
- PUBLIC WATER SUPPLY WELL
- RESIDENTIAL WATER WELL
- INDUSTRIAL WATER WELL

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HUMAN HEALTH RISK ASSESSMENT WORK PLAN

GROUNDWATER MONITORING AND PRIVATE WELL LOCATIONS

FIGURE
5

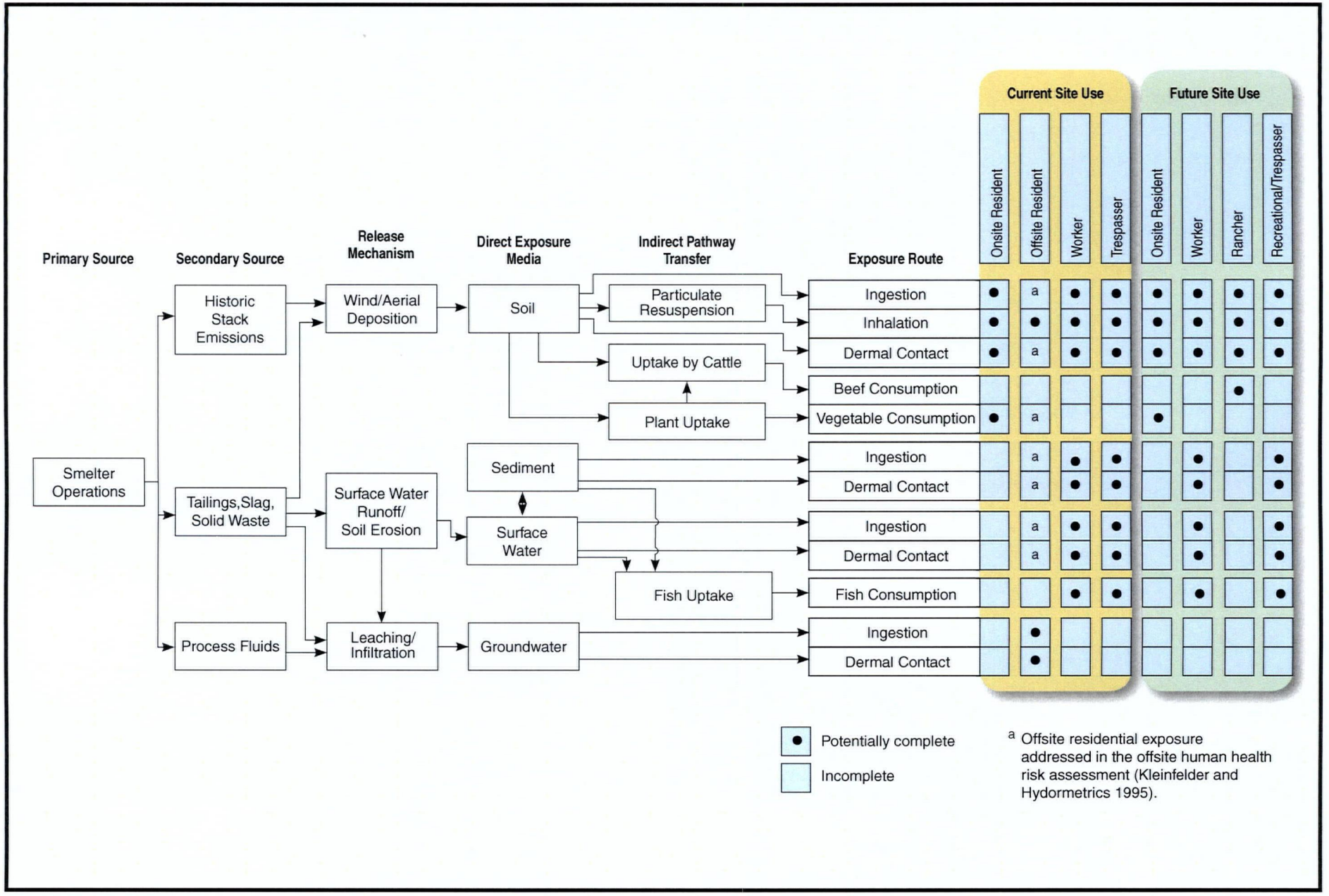

Figure 6. Preliminary conceptual site model for the East Helena smelter site human health risk assessment

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Tables

Table 1. Blood lead summary for East Helena children

Year	Number Screened[a]	Arithmetic Mean (µg/dl)	Number of results <5 µg/dl	Number of results 5 - 10 µg/dl	Number of results 10 - 15 µg/dl	Number of results ≥15 µg/dl
1995	81	5.5	35	39	7	0
1996	86	4.2	56	26	4	0
1997	76	5.8	41	23	8	4
1998	129	3.8	96	27	4	2
1999	48	5.8	19	24	4	1
2000	147	3.7	106	38	3	0
2001	90	2.5	80	10	0	0
2002	38	2.2	38	0	0	0
2003	165	1.6	159	6	0	0
2004	96	2.6	90	6	0	0
2005	10	1.6	10	0	0	0
2006	98	1.3	96	2	0	0
2007	8	1.2	8	0	0	0
2008	133	1.9	125	7	1	0

Source: LCCCHD (2009), 1995-2008 blood lead data for children 0-72 months.

[a] Represents the number of measurements, not individual children

Table 2. Human health screening results for surface soil

Human health screening results for soil ingestion

Chemical (mg/kg dry wt)	Number of Analyses	Number of Detected Values	Site Maximum Concentration	Residential Screening Level[a]	Exceeds Residential Screening Level?	Industrial Screening Level[a]	Exceeds Industrial Screening Level?	Basis for Screening Level[b]
Arsenic	141	135	35,500	40	**Yes**	40	Yes	BG
Cadmium	142	135	23,400	7	**Yes**	81	Yes	RSL
Copper	142	136	35,750	310	**Yes**	4,100	Yes	RSL
Lead	142	142	73,866	400	**Yes**	800	Yes	RSL
Zinc	142	142	88,519	2,300	**Yes**	31,000	Yes	RSL

Human health screening results for surface soil inhalation (dust inhalation pathway)

Chemical (mg/kg dry wt)	Number of Analyses	Number of Detected Values	Site Maximum Concentration	Residential Screening Level[c]	Exceeds Residential Screening Level?	Industrial Screening Level[c]	Exceeds Industrial Screening Level?	Basis for Screening Level[b]
Arsenic	141	135	35500	770	Yes	3900	Yes	RSL
Cadmium	142	135	23400	790	Yes	4000	Yes	RSL
Copper	142	136	35750	--	--	--	--	
Lead	142	142	73866	--	--	--	--	
Zinc	142	142	88519	--	--	--	--	

Notes:

-- - No screening level was available for this chemical.

[a] Residential and industrial total screening levels are based on either the EPA Regional Screening Level (RSL) for residential or industrial soil exposure, respectively (U.S. EPA 2009), or Montana Background, whichever is greater. RSLs based on non-carcinogenic effects were divided by 10, with the exception of the lead screening level. Background is based on mean soil concentrations from Helena Valley (MDEQ 2007). The arsenic background concentration represents the 95%UCL on the mean of background soil arsenic concentratins in Montana (MDEQ 2005).

[b] Basis for screening level:
BG=Background
RSL=EPA Regional Screening Level

[c] Residential and industrial soil inhalation screening levels are based on either the EPA Regional Screening Level (RSL) for residential or industrial soil inhalation exposure, respectively.

Table 3. Human health screening results for sediments

Chemical	Site Maximum Concentration (mg/kg)	Residential Screening Level[a] (mg/kg)	Exceeds Residential Screening Level?	Industrial Screening Level[a] (mg/kg)	Exceeds Industrial Screening Level?	Basis for Screening Level[b]
Aluminum	20,000	7,700	Yes	99,000	No	RSL
Antimony	990	3.1	Yes	41	Yes	RSL
Arsenic	3,030	40	Yes	40	Yes	BG
Barium	352	1,500	No	19,000	No	RSL
Beryllium	2.1	16	No	200	No	RSL
Cadmium	2,680	7	Yes	81	Yes	RSL
Chromium	27.3	280	No	1,400	No	RSL
Cobalt	35.1	2.3	Yes	30	Yes	RSL
Copper	2,600	310	Yes	4,100	No	RSL
Iron	38,100	15,248	Yes	72,000	No	BG/RSL
Lead	14,400	400	Yes	800	Yes	RSL
Manganese	9,030	336	Yes	2,300	Yes	BG/RSL
Mercury	59.1	2.3	Yes	31	Yes	RSL
Nickel	36.4	160	No	2,000	No	RSL
Selenium	432	39	Yes	510	No	RSL
Silver	141	39	Yes	510	No	RSL
Thallium	1,980	0.51	Yes	6.6	Yes	RSL
Vanadium	59.4	39	Yes	520	No	RSL
Zinc	6,930	2,300	Yes	31,000	No	RSL

[a] Residential and industrial screening levels are based on either the EPA Regional Screening Level (RSL) for residential or industrial soil exposure, respectively (U.S. EPA 2009), or Montana Background, whichever is greater. RSLs based on noncarcinogenic effects were divided by 10, with the exception of the lead screening level. Background is based on mean soil concentrations from Helena Valley (MDEQ 2007). The arsenic background concentration represents the 95%UCL on the mean of background soil arsenic concentrations in Montana (MDEQ 2005).

[b] Basis for screening level:
BG=Background
RSL=EPA Regional Screening Level
BG/RSL=Background for residential and EPA Regional Screening Level for industrial.

Table 4. Human health screening results for surface water

Chemical	Site Maximum Concentration (ug/L)	Surface Water Screening Level[a] (ug/L)	Exceeds Surface Water Screening Level?	Basis for Screening Level[b]
Aluminum	1,620	3,700	No	RSL
Antimony	437	6	Yes	MCL
Arsenic	243	10	Yes	MCL
Barium	64	2,000	No	MCL
Beryllium	2.5	4	No	MCL
Cadmium	30.0	5	Yes	MCL
Chromium	5.0	100	No	MCL
Cobalt	25.0	1.1	Yes	RSL
Copper	90	1,300	No	MCL
Iron	8,370	2,600	Yes	RSL
Lead	800	15	Yes	MCL
Manganese	2,180	88	Yes	RSL
Mercury	60 *U*	2	ND>	MCL
Nickel	20.0	73	No	RSL
Selenium	54	50	Yes	MCL
Silver	5.0	18	No	RSL
Thallium	77	2	Yes	MCL
Vanadium	25 *U*	18	ND>*	RSL
Zinc	300	1,100	No	RSL

Notes:

U - Site maximum concentration represents a detection limit for an undetected result.

ND> - Not detected in any sample, but the detection limit exceeded the screening level.

ND>* - Detected results were below the screening level but for some undetected results, the detection limit exceeded the screening level.

[a]If there is a maximum contaminant level (MCL) for a metal, the MCL is used as the surface water screening level. If there is not an MCL, the surface water screening level is the lesser of the Montana Water Quality Standard (MWQS) for human health (MDEQ 2008) and the EPA Regional Screening Level (RSL) for tap water (U.S. EPA 2009). RSLs based on noncarcinogenic effects were divided by 10, with the exception of the lead screening level. All metals that did not exceed an MCL also met the MWQS.

[b] Basis for screening level:
MCL=Maximum Contaminant Level
RSL=EPA Regional Screening Level

Table 5. Human health screening results for private wells

Analyte	Number of Analyses	Number of Detected Values	Site Maximum Concentration		Groundwater Screening Level[a]	Exceeds Groundwater Screening Level?	Basis for Screening Level[b]
Dissolved metals (mg/L)							
Aluminum	192	0	0.05	*U*	3.7	No	RSL
Antimony	192	1	0.0015		0.006	No	MCL
Arsenic	300	112	0.052		0.01	**Yes**	MCL
Barium	192	3	0.058		2	No	MCL
Beryllium	192	0	0.0005	*U*	0.004	No	MCL
Cadmium	300	10	0.002		0.005	No	MCL
Chromium	192	23	0.002	*U*	0.1	No	MCL
Cobalt	192	0	0.005	*U*	0.0011	ND>	RSL
Copper	300	129	0.087		1.3	No	MCL
Iron	300	72	0.6		2.6	No	RSL
Lead	300	0	0.003	*U*	0.015	No	MCL
Manganese	300	37	0.03		0.088	No	RSL
Mercury	192	0	0.003	*U*	0.002	ND>	MCL
Nickel	192	3	0.0038		0.073	No	RSL
Selenium	300	161	0.34		0.05	**Yes**	MCL
Silver	189	0	0.003	*U*	0.018	No	RSL
Thallium	192	2	0.002		0.002	No	MCL
Tin	68	0	0.1	*U*	2.2	No	RSL
Vanadium	192	10	0.02		0.018	**Yes**	RSL
Zinc	300	79	0.056		1.1	No	RSL

Notes:

Undetected results are reported at half the detection limit

-- - No screening level was available for this chemical.

U - not detected in any sample

ND> - not detected in any sample, but the detection limit exceeded the screening level

[a] If there is a maximum contaminant level (MCL) for a metal, the MCL is used as the groundwater screening level. If there is not an MCL, the groundwater screening level is the lesser of the Montana Water Quality Standard (MWQS) for human health (MDEQ 2008) and the EPA Regional Screening Level (RSL) for tap water (U.S. EPA 2009). RSLs based on noncarcinogenic effects were divided by 10, with the exception of the lead screening level. In all cases the MWQS values are greater than or equal to the MCL.

[b] Basis for screening level: MCL=maximum contaminant level; RSL=EPA Regional Screening Level

Table 6. Human health screening results for monitoring wells

Chemical	Number of Analyses	Number of Detected Values	Site Maximum Concentration		Groundwater Screening Level[a]	Exceeds Groundwater Screening Level?	Basis for Screening Level[b]
Dissolved metals (mg/L)							
Aluminum	475	33	2.3		3.7	No	RSL
Antimony	475	96	0.21		0.006	Yes	MCL
Arsenic	1057	872	253		0.01	Yes	MCL
Barium	475	49	0.3		2	No	MCL
Beryllium	475	19	0.004		0.004	No	MCL
Cadmium	1052	224	5.92		0.005	Yes	MCL
Chromium	475	46	0.007		0.1	No	MCL
Cobalt	475	86	0.08		0.0011	Yes	RSL
Copper	1052	227	0.626		1.3	No	MCL
Iron	1052	406	199		2.6	Yes	RSL
Lead	1052	41	0.83		0.015	Yes	MCL
Manganese	1052	566	23.54		0.088	Yes	RSL
Mercury	475	40	0.006		0.002	Yes	MCL
Nickel	475	59	0.07		0.073	No	RSL
Selenium	999	749	3.35		0.05	Yes	MCL
Silver	458	2	0.006		0.018	No	RSL
Thallium	475	51	0.467		0.002	Yes	MCL
Tin	57	0	0.1	*U*	2.2	No	RSL
Vanadium	475	58	0.03		0.018	Yes	RSL
Zinc	1052	330	24.46		1.1	Yes	RSL
Total metals (mg/L)							
Aluminum	37	27	11.4		3.7	Yes	RSL
Antimony	37	16	0.095		0.006	Yes	MCL
Arsenic	135	131	212		0.01	Yes	MCL
Barium	37	9	0.3		2	No	MCL
Beryllium	37	6	0.003		0.004	No	MCL
Cadmium	135	109	7.13		0.005	Yes	MCL
Chromium	37	14	0.015		0.1	No	MCL
Cobalt	37	8	0.07		0.0011	Yes	RSL
Copper	135	102	0.957		1.3	No	MCL
Iron	135	133	217		2.6	Yes	RSL
Lead	135	73	2.78		0.015	Yes	MCL
Manganese	135	131	25		0.088	Yes	RSL
Mercury	37	0	0.003	*U*	0.002	ND>	MCL
Nickel	37	8	0.07		0.073	No	RSL
Selenium	121	82	1.34		0.05	Yes	MCL
Silver	37	3	0.012		0.018	No	RSL
Thallium	37	10	0.231		0.002	Yes	MCL
Tin	13	0	0.05	*U*	2.2	No	RSL
Vanadium	37	8	0.04		0.018	Yes	RSL
Zinc	135	119	27.6		1.1	Yes	RSL

Notes:

– - No screening level was available for this chemical.

U - not detected in any sample

ND> - not detected in any sample, but the detection limit exceeded the screening level

[a] If there is a maximum contaminant level (MCL) for a metal, the MCL is used as the groundwater screening level. If there is not an MCL, the groundwater screening level is the lesser of the Montana Water Quality Standard (MWQS) for human health (MDEQ 2008) and the EPA Regional Screening Level (RSL) for tap water (U.S. EPA 2009). RSLs based on noncarcinogenic effects were divided by 10, with the exception of the lead screening level. In all cases the MWQS values are greater than or equal to the MCL.

[b] Basis for screening level: MCL=maximum contaminant level; RSL=EPA Regional Screening Level

Table 7. Human health screening results for air concentrations at the Firehall monitoring location

Chemical	2000 Monitoring: Annual Mean (ug/m^3)	Residential Screening Level (ug/m^3)	Exceeds Residential Screening Level?
Arsenic[a]	0.056	0.0029	**Yes**
Cadmium[a]	0.03699	0.0068	**Yes**
Chromium (total)[a,b]	0.004	0.001	**Yes**
Copper	3.0098	No RFC	--
Lead[c]	0.845	0.15	**Yes**
Nickel[a]	0.00511	0.0094	No
Zinc	0.43649	No RFC	--

[a]Based on a cancer risk level of 1 in a million

[b]As total Cr (1:6 ratio Cr VI : Cr III) - equivalent to RSL for Cr VI as particulates

[c]Lead Standard--3-month rolling average at http://www.epa.gov/air/criteria.html

Table 8. Soil and sediment exposure parameters for ingestion, dermal contact, and particulate inhalation

Algorithms: (Adult = ages 7 to adult; Child = ages 0 to 6):

Eq 1: Soil Ingestion (Adult A or Child C) Chronic Daily Intake (CDI) (mg/kg-day) =

$(C_{STotal} \times CF \times IR_{[A,C]} \times RBA_{As} \times EF \times ED_{[A,C]}) / (BW_{[A,C]} \times AT)$

Eq. 2: Dermal Contact with Soil (absorbed dose) (Adult A or Child C) Chronic Daily Intake (CDI) (mg/kg-day) =

$(C_{STotal} \times CF \times SA_{[A,C]} \times ABS \times AF_{[A,C]} \times EF \times ED_{[A,C]}) / (BW_{[A,C]} \times AT)$

Eq. 3: Inhalation of Particulates (Adult A or Child C) Exposure Concentration (EC) (ug/m^3) =

$(CA \times ET_{[A,C]} \times EF \times ED_{[A,C]}) / (AT)$

Parameter Code	Parameter Definition	Units	Input Assumptions: Resident	Worker	Recreational User/Trespasser	Rationale
Factors applied in ingestion, dermal, and inhalation estimates						
ED_C	Exposure duration, child	yrs	6	--	--	U.S. EPA (1991)
ED_A	Exposure duration, adult	yrs	24	25	24	U.S. EPA (1991)
BW_C	Body weight, child	kg	15	--	--	U.S. EPA (1991)
BW_A	Body weight, adult	kg	70	70	70	U.S. EPA (1991)
EF	Exposure frequency (adult or child)	days/yr	350	250	100	U.S. EPA (1991), and Site-specific[b]
AT_{nc}	Averaging time, noncarcinogens	days	ED x 365	ED x 365	ED x 365	U.S. EPA (1991)
AT_c	Averaging time, carcinogens	days	25,550	25,550	25,550	U.S. EPA (1991)
Factors applied in both ingestion and dermal estimates						
C_{STotal}	Total exposure to soil and dust calculated as $C_s*F_s+C_D*F_D$					
CF	Conversion factor kg/mg		1.00E-06			
C_S	Soil and outdoor dust arsenic concentration	mg/kg	--	--	--	Exposure unit specific
C_D	Indoor dust concentration [a]	mg/kg	0.43 x C_S	0.43 x C_S	--	Anaconda smelter (CDM 1996)
F_S	Fraction soil/dust ingestion as soil and outdoor dust	fraction	0.45	0.45	0.45	U.S. EPA (1994)
F_D	Fraction soil/dust ingestion as indoor dust	fraction	0.55	0.55	not included	U.S. EPA (1994)
Factors applied in ingestion estimate (Eq. 1)						
IR_C	Soil/dust ingestion rate - child	mg/day	200	--	--	U.S. EPA (1991)
IR_A	Soil/dust ingestion rate - adult resident and worker	mg/day	100	100	--	U.S. EPA (1991)
IR_A	Soil/dust ingestion rate - adult recreational	mg/day	--	--	100	Brattin (2007) See text
RBA_{As}	Relative bioavailability of arsenic[c]	--	0.50	0.50	0.50	Brattin (2007)
Factors applied in dermal estimate (Eq. 2)						
SA_A	Skin surface area available for contact - adult	cm^2/event	5700	3300	5700	U.S. EPA (2004)
SA_C	Skin surface area available for contact -child	cm^2/event	2800	--	--	U.S. EPA (2004)
ABS	Dermal absorption factor[d]	--		Chemical specific		U.S. EPA (2004); Lowney et al. (2007)
AF_A	Soil or sediment-to-skin adherence factor - adult	mg/cm^2	0.07	0.02	0.07	U.S. EPA (2004)
AF_C	Soil or sediment-to-skin adherence factor - child	mg/cm^2	0.2	--	--	U.S. EPA (2004)
Factors applied in inhalation estimate (Eq. 3)[e]						
CA	Air concentration (Estimated from soil data see text)	ug/m^3				U.S. EPA (2009)
ET_A	Exposure time - adult	hours/day	24	8	2	U.S. EPA (2009)
ET_C	Exposure time - child	hour/day	24	--	--	U.S. EPA (2009)

-- Not applicable to this receptor or pathway

[a] Indoor dust concentration is 43 percent of outdoor soil concentration based on arsenic at Anaconda, MT, smelter site. This percentage was higher than those reported at other sites (see text)

[b] The recreational exposure frequency is based on an assumption of 5 days per week for the 19 weeks per year without measurable snowfall in Helena, MT based on national weather service data (http://nowdata.rcc-acis.org/TFX/pubACIS_results).

[c] Bioavailability for railcar and ore storage areas will be based on site-specific bioaccessibility testing and mineralogy analysis; 0.5 will be used for all other areas

[d] Dermal absorption factors are available only for arsenic (0.03 or 0.01) and cadmium (0.01)

[e] Risk estimates for air are derived through comparison with available inhalation unit risk or RfC value

Table 9. Surface water exposure parameters

Algorithms (Ages 7 to adult)

Surface water Ingestion Chronic Daily Intake (CDI) (mg/kg-day) =

$(C_{SW} \times IR \times EF \times ED) / (BW \times AT)$

Dermal Contact with Surface Water (absorbed dose) Chronic Daily Intake (CDI) (mg/kg-day) =

$(C_{SW} \times CF \times SA \times PC \times ET \times EF \times ED) / (BW \times AT)$

Parameter Code	Parameter Definition	Units	Recreational User/Trespasser Resident	Rationale
C_{SW}	Surface water concentration	mg/L	--	Site-specific
EF	Exposure frequency	days/yr	100	Site-specific[a]
ED_A	Exposure duration	yrs	24	U.S. EPA (1991)
BW_A	Body weight	kg	70	U.S. EPA (1991)
AT_c	Averaging time, carcinogens	days	25,550	U.S. EPA (1991)
AT_{nc}	Averaging time, noncarcinogens	days	ED x 365	U.S. EPA (1991)
Factors applied in ingestion estimate				
IR_W	Surface water incidental ingestion rate (adult or child)	L/hour	0.03	U.S. EPA (1998)
Factors applied in dermal estimate			**Swimming / Wading**	
ET	Exposure time	hour/day	1	U.S. EPA (1998)
CF	Volumetric conversion factor 1 liter/ 1000 cm^3	0.001		
SA_A	Skin surface area available for contact - Adult	cm^2/event	18000 / 4500[b]	U.S. EPA (2004 [Exhibit 3-2])
PC	Chemical-Specific	cm/hour		U.S. EPA (2004 [Exhibit 3-1])

[a] The recreational exposure frequency is based on an assumption of 5 days per week for the 19 weeks per year without measurable snowfall in Helena, MT, based on national weather service data (http://nowdata.rcc-acis.org/TFX/pubACIS_results).

[b] Wading dermal surface area represents 25 percent of the whole body surface area identified in U.S. EPA (2004)

Table 10. Groundwater exposure parameters

Algorithms (Ages 0 to adult):

Groundwater Ingestion (chronic exposure) Chronic Daily Intake (CDI) (mg/kg-day) =

$(C_{GW} \times IR \times EF \times ED) / (BW \times AT)$

Dermal Contact with Groundwater (absorbed dose) (chronic exposure) Chronic Daily Intake (CDI) (mg/kg-day) =

$(C_{GW} \times CF \times SA \times PC \times ET \times EF \times ED) / (BW \times AT)$

Parameter Code	Parameter Definition	Units	Offsite Resident	Rationale
C_{GW}	Groundwater concentration	mg/L	--	Site-specific
ED	Exposure duration, chronic exposure	years	70	U.S. EPA (1991)
BW	Body weight	kg	70	U.S. EPA (1991)
EF	Exposure frequency	days/year	365	U.S. EPA (1991)
AT_c	Averaging time, carcinogens	days	25,550	U.S. EPA (1991)
AT_{nc}	Averaging time, noncarcinogens	days	ED x 365	U.S. EPA (1991)
Factors applied in ingestion estimate				
IR_W	Water ingestion rate	L/day	2	U.S. EPA (1991)
Factors applied in dermal estimate			**Bathing**	
CF	Volumetric conversion factor 1 liter/ 1,000 cm^3	0.001		
ET	Exposure time	hour/day	1	U.S. EPA (1998)
SA	Skin surface area available for contact	cm^2/event	18000	U.S. EPA (2004 [Exhibit 3-2])
PC	Chemical-Specific	cm/hr		U.S. EPA (2004 [Exhibit 3-1])

Table 11. Homegrown vegetable exposure parameters

Algorithms: (Ages 0 to adult)

Eq 1: Home-grown vegetable consumption Chronic Daily Intake (CDI) (mg/kg-day) =

$(((C_{rootveg} \times IR_{root} \times FAP_{root}) + (C_{leafy} \times IR_{leafy} \times FAP_{leafy})) \times ED) / (AT)$

Parameter Code	Parameter Definition	Units	Input Assumptions Onsite Resident	Rationale
$C_{rootveg}$ or C_{leafy}	Calculated based on soil concentration and uptake factor equations for root and leafy vegetables			Glass and SAIC 1992
$IR_{rootveg}$	75th percentile, consumption of root vegetables, Western U.S. Consumers only All ages	g/kg-day	0.98	U.S. EPA (1997) Table 13-65
IR_{leafy}	75th percentile consumption of exposed vegetables, Western U.S. Consumers only All ages	g/kg-day	2.1	U.S. EPA (1997) Table 13-63
FAP_{root} [a]	Fraction remaining after preparation of root vegetables	%	76.5	U.S. EPA (1997) Table 13-7
$FAPL_{leafy}$ [a]	Fraction remaining after preparation of leafy vegetables	%	83.5	U.S. EPA (1997) Table 13-7
ED	Exposure duration (child and adult combined)	years	30	U.S. EPA (1991)
AT_{nc}	Averaging time, noncarcinogens	days	ED x 365	U.S. EPA (1991)
AT_c	Averaging time, carcinogens	days	25,550	U.S. EPA (1991)

[a]Adjustment for weight loss during preparation (U.S. EPA 1997; Table 13-7):

Root	% loss	Leafy	% loss
beets	28	cabbage	11
carrots	19	lettuce	22
Average	23.5	Average	16.5
Fraction after preparation	76.5		83.5

Table 12. Input parameters for the adult lead model

Algorithms: (Ages 7 to adult)

Eq 1: Adult blood lead, geometric mean (PbB_{adult})

$$PbB_{adult}\ (\mu g/dL) = PbB_0 + (BKSF \times (IR_{S\text{-}D} \times ((Pb_S \times F_S) + (Pb_D \times F_D)) \times AF \times (EF/AT))$$

Eq 2: 95th percentile PbB among fetuses of adult workers ($PbB_{fetal,\ 0.95}$)

$$PbB_{fetal,\ 0.95}\ (\mu g/dL) = PbB_{adult} \times GSD_i^{1.645} \times R_{fetal/maternal}$$

Parameter Code	Parameter Definition	Units	Input Assumptions[a] Occupational	Recreational/ Trespasser	Rationale
PbS	Soil lead	mg/kg	--	--	site specific
PbD	Indoor dust lead	mg/kg	0.17 × PbS	--	U.S. EPA (2005)[b]
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.90	0.90	U.S. EPA (1996b)
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4	0.4	U.S. EPA (1996b)
GSD_i	Geometric standard deviation PbB	--	1.5	1.5	Walker (1996)
PbB_0	Baseline PbB	µg/dL	1.0	1.0	U.S. EPA (2009)
$IR_{S\text{-}D}$	Soil and dust ingestion rate (includes soil-derived indoor dust)	g/day	0.05	0.05	U.S. EPA (1996b)
F_S	Fraction of soil/dust ingestion as outdoor soil	--	0.45	0.45	U.S. EPA (1994b)
F_D	Fraction of soil/dust ingestion as indoor dust	--	0.55	0	U.S. EPA (1994b)[b]
AF	Absorption fraction (same for soil and dust)	--	0.12	0.12	U.S. EPA (1996b)[c]
EF	Exposure frequency	days/year	219	60	U.S. EPA (1996b), professional judgement[d]
AT	Averaging time	days/year	365	132	U.S. EPA (1996b)[e]
PbB_t	Target PbB level of concern for the fetus	µg/dL	10	10	U.S. EPA (1996b)

Notes:

[a]All exposure assumptions are the same by U.S. EPA (Brattin 2007) with the following exceptions: 1) baseline blood lead (PbB0) was updated to incorporate new U.S. EPA (2009) recommendations, and 2) an inter-individual GSD of 1.5 was applied, consistent with U.S. EPA Region 8 recommendations (Walker 1996).

[b]Indoor dust exposure is not included for recreational/trespasser exposure, only outdoor soil for the site.

[c]*In vitro* bioaccessibility and soil mineralogy studies will be conducted for the slag pile area (slag) and the rail car staging area (ore spillage) to support derivation of a site-specific relative lead bioavailability factor to replaced the default if justified.

[d]Assumes visits involving soil ingestion at the site would occur on snow-free (i.e., warmer) days or weeks. National weather service data indicates on average 132 days per year have no snow fall in Helena, Montana. Assuming a conservative central tendency frequency of visits of 3 out of 7 snow-free days days, gives 57 days/year, or 60 days/year after rounding up.

[e]The averaging time represents the period of time over which steady state exposure conditions occur. For the trespasser/recreational scenario that is the 132

Appendix A

Detailed Results of Preliminary CoPC Screening

Table A-1. Detailed results of human health residential screening of surface soil

					Arsenic (mg/kg dry)	Cadmium (mg/kg dry)	Copper (mg/kg dry)	Lead (mg/kg dry)	Zinc (mg/kg dry)
Number of analyses					141	142	142	142	142
Number of detected values					135	135	136	142	142
Site Maximum Concentration					35,500	23,400	35,750	73,866	88,519
Helena Valley Mean Soil					40	0.24	16	11.6	46.9
Residential Soil Screening Level[a]					40	7.0	310	400	2,300
Exceeds Residential Soil Screening Level?					**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Industrial Soil Screening Level[a]					40	81.0	4,100	800	31,000
Exceeds Industrial Soil Screening Level?					**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Basis for Screening Level[b]					BG	RSL	RSL	RSL	RSL
Residential Soil Inhalation Screening Level[c]					770	790	--	--	--
Exceeds Residential Screening Level?					**Yes**	**Yes**	--	--	--
Industrial Soil Inhalation Screening Level[c]					3,900	4,000	--	--	--
Exceeds Industrial Screening Level?					**Yes**	**Yes**	--	--	--
Station description	Date	Sample ID	Upper depth (in.)	Lower depth (in.)					
LOS-SS01	4/5/2001	LOS-SS01-1	0	4	82	3 *U*	137	396	833
LOS-SS02	4/5/2001	LOS-SS02-1	0	4	151	19	795	749	266
LOS-SS03	3/13/2001	LOS-SS03-1	0	4		30	146	781	463
LOS-SS05	4/5/2001	LOS-SS05-1	0	4	3,192	329	2,507	2,528	846
LOS-SS05	1/1/2001	SS-5	0	1	1,495	1,093	8,850	21,875	46,625
LOS-SS06	4/6/2001	LOS-SS06-1	0	4	0.027	23	0.066	573	480
LOS-SS06	1/1/2001	SS-6	0	1	3,300	253	4,200	19,400	3,975
LOS-SS07	4/5/2001	LOS-SS07-1	0	4	89	410	78	10,472	14,347
LOS-SS07	1/1/2001	SS-7	0	1	3,400	373	8,500	22,350	43,725
LOS-SS08	3/13/2001	LOS-SS08-1	0	4	396	3 *U*	1,015	249	244
LOS-SS08	1/1/2001	SS-8	0	1	3,800	1,013	18,600	21,400	14,250
LOS-SS09	3/15/2001	LOS-SS09-1	0	4	2,310	170	3,617	3,413	3,374
LOS-SS10	4/6/2001	LOS-SS10-1	0	4	1,476	351	2,081	2,129	1,735
LOS-SS10	1/1/2001	SS-10	0	1	3,900	1,613	8,350	23,900	30,425
LOS-SS11	3/15/2001	LOS-SS11-1	0	4	59	374	201	28,250	11,690
LOS-SS12	4/6/2001	LOS-SS12-1	0	4	1,007	628	1,522	13,249	17,232
LOS-SS13	3/13/2001	LOS-SS13-1	0	4	367	24	532	669	457
LOS-SS14	3/15/2001	LOS-SS14-1	0	4	311	277	1,247	7,975	4,387
LOS-SS15	3/13/2001	LOS-SS15-1	0	4	340	201	1,134	2,475	3,536
LOS-SS16	3/15/2001	LOS-SS16-1	0	4	1,816	109	3,299	2,675	7,529
LOS-SS19	1/1/2001	SS-19	0	1	21,625	2,373	19,850	20,250	23,300
LOS-SS22	1/1/2001	SS-22	0	1	3,100	2,213	11,300	21,950	23,625
LOS-SS16A	5/14/2001	LOS-SS16A-1	0	2	276	208	797	3,331	2,668
LOS-SS16B	7/19/2001	LOS-SS16B-1	0	2	261	216	812	3,361	3,002
RC-SS01	4/16/2001	RC-SS1-1	0	4	58	211	139	5,244	10,227
RC-SS03	4/16/2001	RC-SS3-1	0	4	746	542	2,127	5,445	10,755
RC-SS04	4/6/2001	RC-SS04-1	0	4	45	1,530	199	28,239	9,307
RC-SS05A	4/6/2001	RC-SS05A-1	0	4	1,532	283	3,877	5,904	2,921
RC-SS05B	4/6/2001	RC-SS05B-1	0	4	3,522	29	9,282	238	88
RC-SS05C	4/6/2001	RC-SS05C-1	0	4	5,468	370	9,784	8,216	2,763
RC-SS06	4/6/2001	RC-SS06-1	0	4	8,016	6,236	17,164	31,161	13,165
RC-SS07A	4/9/2001	RC-SS07A-1	0	4	684	1,394	9,381	53,696	13,476
RC-SS07B	4/9/2001	RC-SS07B-1	0	4	5,757	1,536	11,769	63,648	24,378
RC-SS07C	4/9/2001	RC-SS07C-1	0	4	3,799	39	15,727	7,687	70,223
RC-SS07D	4/9/2001	RC-SS07D-1	0	4	4,984	1,646	22,282	64,192	15,105
RC-SS07E	4/9/2001	RC-SS07E-1	0	4	4,148	12,026	8,269	39,780	30,603
RC-SS08	4/9/2001	RC-SS08-1	0	4	3,735	11,553	6,220	38,210	23,906
RC-SS09A	4/6/2001	RC-SS09A-1	0	4	710	1,724	7,611	34,735	12,015
RC-SS09B	4/6/2001	RC-SS09B-1	0	4	3,209	1,796	9,454	20,266	18,773
RC-SS09C	4/6/2001	RC-SS09C-1	0	4	2,726	39	6,098	7,325	64,327
RC-SS09D	4/6/2001	RC-SS09D-1	0	4	727	5,911	15,421	35,560	19,871
RC-SS10	4/6/2001	RC-SS10-1	0	4	1,153	5,441	5,442	32,453	25,385
RC-SS11	4/16/2001	RC-SS11-1	0	4	5,259	249	7,002	21,428	16,770
RC-SS11	1/1/2001	SS-11	0	1	6,525	5,800	20,700	22,100	67,175
RC-SS12	4/10/2001	RC-SS12-1	0	4	0.011	45	0.088	1,312	282
RC-SS12	1/1/2001	SS-12	0	1	35,500	5,325	31,450	19,975	63,650
RC-SS13	4/10/2001	RC-SS13-1	0	4	1,970	2,437	5,410	48,087	21,586
RC-SS14	1/1/2001	SS-14	0	1	1,098	212	1,918	8,900	30,125
RC-SS14A	4/10/2001	RC-SS14A-1	0	4	1,690	955	3,886	19,220	6,270
RC-SS14B	4/10/2001	RC-SS14B-1	0	4	4,671	1,271	7,910	30,364	9,662
RC-SS14C	4/10/2001	RC-SS14C-1	0	4	532	2,861	3,134	31,634	11,185
RC-SS14D	4/10/2001	RC-SS14D-1	0	4	4,066	12,547	13,741	61,751	31,230
RC-SS15	4/10/2001	RC-SS15-1	0	4	2,767	288	4,801	7,073	7,903
RC-SS17	4/18/2001	RC-SS17-1	0	4	4,009	1,123	17,296	73,866	26,044
RC-SS17	1/1/2001	SS-17	0	1	795	212	1,813	6,200	2,235

Table A-1. (cont.)

Station description	Date	Sample ID	Upper depth (in)	Lower depth (in)	Arsenic (mg/kg dry)	Cadmium (mg/kg dry)	Copper (mg/kg dry)	Lead (mg/kg dry)	Zinc (mg/kg dry)
RC-SS18	4/18/2001	RC-SS18-1	0	4	0.05 *U*	888	0.11	14,220	4,384
RC-SS18	1/1/2001	SS-18	0	1	13,450	23,400	29,200	19,325	67,175
RC-SS19	4/18/2001	RC-SS19-1	0	4	3,225	1,646	15,183	29,364	13,191
RC-SS20	4/18/2001	RC-SS20-1	0	4	3,034	1,319	12,210	34,897	24,990
RC-SS20	1/1/2001	SS-20	0	1	5,450	1,733	18,625	19,225	26,275
RC-SS23	4/26/2001	RC-SS23-1	0	4	1,299	195	1,987	7,283	8,466
RC-SS24	4/16/2001	RC-SS24-1	0	4	0.05 *U*	824	0.05 *U*	9,397	25,406
RC-SS25	4/18/2001	RC-SS25-1	0	4	4,107	213	13,802	16,603	88,519
RC-SS26	4/18/2001	RC-SS26-1	0	4	3,712	395	10,085	14,615	22,280
RC-SS27	4/9/2001	RC-SS27-1	0	4	3,226	1,528	6,768	45,482	22,831
RC-SS28	4/9/2001	RC-SS28-1	0	4	0.05 *U*	2,252	0.58	50,060	18,195
RC-SS29	4/10/2001	RC-SS29-1	0	4	1,428	761	4,178	56,700	22,202
RC-SS2A	4/16/2001	RC-SS2A-1	0	4	1,159	280	2,455	15,755	7,916
RC-SS2B	4/16/2001	RC-SS2B-1	0	4	322	513	538	15,258	8,770
RC-SS2C	4/16/2001	RC-SS2C-1	0	4	736	427	6,977	11,559	5,854
RC-SS2D	4/16/2001	RC-SS2D-1	0	4	0.05 *U*	251	0.05 *U*	2,898	1,830
RCSA-01A	4/23/2001	RC-SA01A-1	0	4	1,173	118	2,757	8,064	3,404
RCSA-01B	4/23/2001	RC-SA01B-1	0	4	1,727	547	7,162	30,611	18,686
RCSA-01C	4/20/2001	RC-SA01C-1	0	4	1,593	600	4,384	16,890	21,098
RCSA-01D	4/20/2001	RC-SA01D-1	0	4	656	1,065	2,126	30,659	11,986
RCSA-01E	4/20/2001	RC-SA01E-1	0	4	926	354	2,767	30,206	15,772
RCSA-02A	4/24/2001	RC-SA02A-1	0	4	902	528	1,832	14,681	8,704
RCSA-02B	4/24/2001	RC-SA02B-1	0	4	604	700	4,382	19,234	13,173
RCSA-02C	4/24/2001	RC-SA02C-1	0	4	533	381	2,785	15,507	13,353
RCSA-02D	4/24/2001	RC-SA02D-1	0	4	191	173	35,750	8,989	7,970
RCSA-02E	4/24/2001	RC-SA02E-1	0	4	1,634	151	4,305	8,264	11,321
RCSA-02F	4/24/2001	RC-SA02F-1	0	4	3,255	40	10,724	1,913	3,611
RCSA-03	4/26/2001	RCSA-3-1	0	4	956	2,875	4,770	60,365	39,068
RCSA-04	4/24/2001	RC-SA04-1	0	4	2,464	665	3,196	32,348	21,874
RCSA-05A	4/24/2001	RC-SA05A-1	0	4	3,511	488	6,447	61,147	41,638
RCSA-05B	4/23/2001	RC-SA05B-1	0	4	3,407	672	9,688	54,667	34,496
RCSA-05C	4/23/2001	RC-SA05C-1	0	4	2,358	1,185	6,009	62,282	52,549
RCSA-05D	4/23/2001	RC-SA05D-1	0	4	2,067	1,048	6,317	61,424	33,013
RCSA-05E	4/23/2001	RC-SA05E-1	0	4	2,880	767	12,208	39,682	26,441
RCSA-05F	4/23/2001	RC-SA05F-1	0	4	2,593	751	5,903	32,478	19,404
RCSA-06	4/24/2001	RC-SA06-1	0	4	3,889	527	7,271	46,977	71,979
RCSA-07	4/25/2001	RC-SA07-1	0	4	3,234	683	10,354	47,871	34,445
RCSA-08A	4/25/2001	RC-SA08A-1	0	4	1,411	809	2,755	58,640	37,734
RCSA-08B	4/25/2001	RC-SA08B-1	0	4	1,049	649	3,158	55,755	39,989
RCSA-08C	4/25/2001	RC-SA08C-1	0	4	763	195	2,114	22,576	14,419
RCSA-08D	4/25/2001	RC-SA08D-1	0	4	5,516	264	7,755	18,475	11,613
RCSA-08E	4/25/2001	RC-SA08E-1	0	4	6,171	238	13,210	13,901	8,891
UOP-SS01	3/29/2001	UOP-SS01-1	0	4	0.05 *U*	137	0.05 *U*	2,991	1,734
UOP-SS02	3/29/2001	UOP-SS02-1	0	4	324	227	342	7,958	12,492
UOP-SS03	3/29/2001	UOP-SS03-1	0	4	91	39	268	1,534	730
UOP-SS04	3/29/2001	UOP-SS04-1	0	4	25	69	96	2,619	1,266
UOP-SS05	3/29/2001	UOP-SS05-1	0	4	19	38	89	1,380	657
UOP-SS06	3/8/2001	UOP-SS06-1	0	4	60	3 *U*	150	277	155
UOP-SS07	3/8/2001	UOP-SS07-1	0	4	238	3 *U*	501	82	85
UOP-SS08	3/8/2001	UOP-SS08-1	0	4	540	32	1,702	632	314
UOP-SS09	3/8/2001	UOP-SS09-1	0	4	236	116	133	2,199	1,001
UOP-SS10	3/8/2001	UOP-SS10-1	0	4	0.47	532	0.05 *U*	7,634	5,319
UOP-SS11	3/8/2001	UOP-SS11-1	0	4	124	99	3,903	2,071	674
UOP-SS12	3/22/2001	UOP-SS12-1	0	4	81	71	467	2,371	2,843
UOP-SS13	3/22/2001	UOP-SS13-1	0	4	34	28	314	884	576
UOP-SS14	3/22/2001	UOP-SS14-1	0	4	25	16	186	757	738
UOP-SS15	1/1/2001	SS-15	0	1	385	172	9,750	3,250	3,975
UOP-SS15	3/22/2001	UOP-SS15-1	0	4	48	10	258	472	1,594
UOP-SS16	1/1/2001	SS-16	0	1	121	92	16,375	1,368	1,868
UOP-SS16	3/22/2001	UOP-SS16-1	0	4	29	3 *U*	235	216	135
UOP-SS17	3/22/2001	UOP-SS17-1	0	4	145	3 *U*	415	552	1,377
UOP-SS18	3/22/2001	UOP-SS18-1	0	4	101	3 *U*	200	307	189
UOP-SS19	3/21/2001	UOP-SS19-1	0	4	387	80	500	2,706	2,585
UOP-SS20	3/21/2001	UOP-SS20-1	0	4	0.05 *U*	28	0.05 *U*	1,094	946
UOP-SS21	3/21/2001	UOP-SS21-1	0	4	3,121	79	3,346	3,811	1,816
UOP-SS23	1/1/2001	SS-23	0	1	121	212	320	11,600	1,093
UOS-SS01	1/1/2001	SS-1	0	1	6,075	6,000	14,575	19,350	23,625
UOS-SS01	4/17/2001	UOS-SS01-1	0	4	8,091	1,607	23,599	5,186	2,768
UOS-SS02	1/1/2001	SS-2	0	1	3,475	1,813	3,225	24,975	10,050
UOS-SS02	4/17/2001	UOS-SS02-1	0	4	39	10,646	88	28,537	19,494
UOS-SS04	1/1/2001	SS-4	0	1	5,650	14,725	12,175	23,625	44,050
UOS-SS04	4/26/2001	UOS-SS4-1	0	4	735	39	639	443	367

Table A-1. (cont.)

Station description	Date	Sample ID	Upper depth (in)	Lower depth (in)	Arsenic (mg/kg dry)	Cadmium (mg/kg dry)	Copper (mg/kg dry)	Lead (mg/kg dry)	Zinc (mg/kg dry)
UOS-SS05	4/17/2001	UOS-SS05-1	0	4	1,868	40	3,515	376	137
UOS-SS24	1/1/2001	SS-24	0	1	2,115	613	4,275	16,575	7,325
UPS-SS07	3/16/2001	UPS-SS07-1	0	4	0.11	945	0.05 *U*	10,425	6,421
UPS-SS08	3/15/2001	UPS-SS08-1	0	4	483	80	1,296	2,624	1,347
UPS-SS09	3/20/2001	UPS-SS09-1	0	4	334	31	1,100	917	1,611
UPS-SS10	3/20/2001	UPS-SS10-1	0	4	1,191	105	4,101	2,439	5,345
UPS-SS11	3/16/2001	UPS-SS11-1	0	4	1,748	116	8,221	3,255	3,560
UPS-SS12	3/16/2001	UPS-SS12-1	0	4	5,955	192	4,039	14,172	12,858
UPS-SS13	3/20/2001	UPS-SS13-1	0	4	21	843	40	14,989	8,045
UPS-SS14	3/20/2001	UPS-SS14-1	0	4	18	1,160	23	21,303	41,988
UPS-SS21	1/1/2001	SS-21	0	1	17,075	1,693	35,350	22,575	14,875
UPS-SS28	1/1/2001	SS-28	0	1	8,625	2,525	23,600	1,535	23,925
UPS-SS29	1/1/2001	SS-29	0	1	9,525	2,575	23,700	20,300	48,550
UPS-SS30	1/1/2001	SS-30	0	1	1,633	373	5,600	12,725	7,925
UPS-SS31	1/1/2001	SS-31	0	1	2,625	813	6,900	14,600	84,650

Notes:

Undetected results are reported at half the detection limit

– - No screening level was available for this chemical.
U - not detected in any sample

[a] Residential and industrial screening levels are based on either the EPA Regional Screening Level (RSL) for residential or industrial soil exposure, respectively, or Montana Background, whichever is greater. RSLs based on noncarcinogenic effects were divided by 10, with the exception of the lead screening level. Background is based on mean soil concentrations from Helena Valley (MDEQ 2007). The arsenic background concentration represents the 95%UCL on the mean of background soil arsenic concentrations in Montana (MDEQ 2005).

[b] Basis for screening level:
BG=Background
RSL=EPA Regional Screening Level
BG/RSL=Background for residential and EPA Regional Screening Level for Industrial.

[c] Residential and industrial soil inhalation screening levels are based on either the EPA Regional Screening Level (RSL) for residential or industrial soil inhalation exposure, respectively. RSLs based on noncarcinogenic effects were divided by 10.

Table A-2. Detailed results of human health residential screening of sediments

Chemical (mg/kg dry wt)	Sediment Screening Criteria: Background	Residential RSL	Exceeds Screening Level?[a]	Reference: Max	CFR_1	CFR_2	PPC_1
Aluminum	--	7,700	Yes	17600	13200	17600	8590
Antimony	--	3.1	ND>	12.1 *U*	11.6 *U*	12.1 *U*	*R*
Arsenic	40	0.39	No	15.6	12.4	15.6	11.5
Barium	--	1,500	No	175	166	175	106
Beryllium	--	16	No	1.8	1.5	1.8	0.91
Cadmium	0.24	7	No	3.5	0.97	1.2	3.5
Chromium	--	280	No	23.6	21.2	23.6	18
Cobalt	--	2.3	Yes	9.9	8.4	9.3	9.9
Copper	16	310	No	59.7	28.1	33.6	59.7
Iron	15,248	5,500	Yes	20700	16100	19500	20700
Lead	11.6	400	No	104	17.2	23.5	104
Manganese	336	180	Yes	720	198	258	720
Mercury	0.08	2.3	No	0.15 *U*	0.11 *U*	0.145 *U*	*R*
Nickel	--	160	No	18.8	16.8	18.8	10.4
Selenium	0.07	39	No	7.1 *U*	6.75 *U*	7.05 *U*	*R*
Silver	--	39	No	2.0 *U*	1.95 *U*	2 *U*	*R*
Thallium	--	0.51	ND>	5.1 *U*	4.85 *U*	5.05 *U*	*R*
Vanadium	--	39	Yes	39.7	24.1	27.8	39.7
Zinc	46.9	2,300	No	454	81.4	102	454

Chemical (mg/kg dry wt)	Sediment Screening Criteria: Background	Residential RSL	Exceeds Screening Level?[a]	Lower Lake: Max	LL_1	LL_2	LL_3
Aluminum	--	7,700	Yes	13000	4440	13000	11500
Antimony	--	3.1	Yes	990	990	353	530
Arsenic	40	0.39	Yes	3030	1660	2730	3030
Barium	--	1,500	No	245	173	245	205
Beryllium	--	16	No	1.8	0.56	1.8	1.3
Cadmium	0.24	7	Yes	2680	1230	1150	2680
Chromium	--	280	No	22.1	10.4	22.1	21.9
Cobalt	--	2.3	Yes	35.1	25.6	35.1	34.6
Copper	16	310	Yes	2600	1920	1900	2600
Iron	15,248	5,500	Yes	35200	17500	35200	30300
Lead	11.6	400	Yes	14400	9470	9420	14400
Manganese	336	180	Yes	1370	851	1230	1370
Mercury	0.08	2.3	Yes	53.3	53.3	38	48.4
Nickel	--	160	No	36.4	24.7	36.4	34
Selenium	0.07	39	Yes	432	432	221	316
Silver	--	39	Yes	141	101	93.7	141
Thallium	--	0.51	Yes	1980	1980	700	884
Vanadium	--	39	Yes	57.7	20.4	57.7	44.4
Zinc	46.9	2,300	Yes	6930	4490	6080	6930

Table A-2 (cont.)

Chemical (mg/kg dry wt)	Sediment Screening Criteria: Background	Sediment Screening Criteria: Residential RSL	Exceeds Screening Level?[a]	Prickly Pear Creek: Max	PPC_2	PPC_3	PPC_4	PPC_5
Aluminum	--	7,700	Yes	10100	7750	9500	10100	4880
Antimony	--	3.1	Yes	4.5	7.75 *U*	4.1	4.5	1.9
Arsenic	40	0.39	Yes	250	52.1	122	250	32.1
Barium	--	1,500	No	352	135	250	352	85.3
Beryllium	--	16	No	1.4	1.1	1.3	1.4	0.63
Cadmium	0.24	7	Yes	36.8	6	22.8	36.8	4.1
Chromium	--	280	No	21.2	10.3	15.9	21.2	8.2
Cobalt	--	2.3	Yes	21.2	12.3	15.5	21.2	7
Copper	16	310	Yes	480	93.9	221	480	44.1
Iron	15,248	5,500	Yes	38100	18600	24800	38100	11800
Lead	11.6	400	Yes	1090	370	878	1090	203
Manganese	336	180	Yes	9030	672	3920	9030	558
Mercury	0.08	2.3	Yes	3.1	0.43	2.5	3.1	0.27
Nickel	--	160	No	16.1	9.9	12.7	16.1	6.2
Selenium	0.07	39	No	5.3	1.3	2.8	5.3	1.1
Silver	--	39	No	2.5	1.3 *U*	0.85	2.5	1.2 *U*
Thallium	--	0.51	ND>	3.3 *U*	3.25 *U*	*R*	*R*	3 *U*
Vanadium	--	39	Yes	55.2	34	44.1	55.2	24.8
Zinc	46.9	2,300	Yes	3930	925	1860	3930	444

Chemical (mg/kg dry wt)	Sediment Screening Criteria: Background	Sediment Screening Criteria: Residential RSL	Exceeds Screening Level?[a]	Upper Lake/Marsh Area: Max	ULM_1	ULM_2	ULM_3	ULM_4	ULM_5	ULM_6
Aluminum	--	7,700	Yes	20000	15700	14500	15700	11900	9490	20000
Antimony	--	3.1	Yes	112	19.5	1.7	5.6	16.8	10.9	68.6
Arsenic	40	0.39	Yes	581	229	121	162	116	124	326
Barium	--	1,500	No	282	150	213	282	143	111	228
Beryllium	--	16	No	2.1	1.5	1.9	2.1	1.2	1	1.9
Cadmium	0.24	7	Yes	338	112	12.2	66.9	42.5	46.6	199
Chromium	--	280	No	27.3	19.5	20.5	22.3	15.6	13.1	26.7
Cobalt	--	2.3	Yes	24.1	12.2	17.5	19.2	11.5	9.1	18.8
Copper	16	310	Yes	2290	686	191	430	404	332	1270
Iron	15,248	5,500	Yes	34400	23500	32600	29200	18400	16000	34400
Lead	11.6	400	Yes	10400	4270	594	1470	1170	1610	5360
Manganese	336	180	Yes	2520	720	2520	955	576	484	747
Mercury	0.08	2.3	Yes	59.1	14.2	0.59	4.7	5.9	14.5	27.3
Nickel	--	160	No	24.8	17.9	16.2	20.1	12.1	10.1	22.5
Selenium	0.07	39	No	20.4	14	2.8	4.3	4.5	3.8	14
Silver	--	39	Yes	127	29.1	0.65	10.2	14	11.9	59.3
Thallium	--	0.51	Yes	5.25	1.9	*R*	*R*	5.25	4.15 *U*	4.8
Vanadium	--	39	Yes	59.4	41.9	56.2	50.4	34	34.3	58.9
Zinc	46.9	2,300	Yes	6550	1810	1680	3540	2100	1680	4200

Table A-2 (cont.)

Chemical (mg/kg dry wt)	Upper Lake/Marsh Area						
	ULM_7	ULM_8	ULM_9	ULM_10	ULM_11	ULM_12	ULM_12
Aluminum	9650	12200	15600	14200	17500	15900	15900
Antimony	1.2	6.5	0.43	60	112	64.9	64.9
Arsenic	54.6	297	146	337	581	452	452
Barium	120	149	214	179	201	228	228
Beryllium	1	1.3	1.7	1.6	2	2	2
Cadmium	15	38.3	17.7	238	338	316	316
Chromium	12.4	15.8	20.9	20.1	27.3	24.7	24.7
Cobalt	8.6	13.6	17.4	18	24.1	21.5	21.5
Copper	158	391	180	1310	2290	1970	1970
Iron	16300	19300	26200	25600	30200	29300	29300
Lead	486	1850	529	5140	10400	8990	8990
Manganese	472	890	755	911	1300	1190	1190
Mercury	1.2	10.1	2.1	28.3	50.6	59.1	59.1
Nickel	9.3	13.4	17.9	19.6	24.8	23	23
Selenium	3.2	5.2	2.9	11.5	19.9	20.4	20.4
Silver	2.7	14.2	1.3 *U*	64.1	127	107	107
Thallium	4.25 *U*	3.3 *U*	3.2 *U*	*R*	*R*	*R*	*R*
Vanadium	27.1	46.2	57.5	43.6	59.4	52.4	52.4
Zinc	1360	2120	1670	4260	6550	6420	6420

Notes:

R - Rejected

U - not detected, reported at half the detection limit.

Units are mg/kg dry weight.

[a] Residential screening levels are based on either the EPA Regional Screening Level (RSL) for residential soil exposure or Montana Background, whichever is greater. RSLs based on noncarcinogenic effects were divided by 10, with the exception of the lead screening level. Background is based on mean soil concentrations from Helena Valley (MDEQ 2007). The arsenic background concentration represents the 95%UCL on the mean of background soil arsenic concentrations in Montana (MDEQ 2005).

Table A-3. Detailed results of human health industrial screening of sediments

Chemical (mg/kg dry wt)	Sediment Screening Criteria: Background	Industrial RSL	Exceeds Screening Level?[a]	Reference: Max	CFR_1	CFR_2	PPC_1
Aluminum	--	99,000	No	17600	13200	17600	8590
Antimony	--	41	No	12.1 U	11.6 U	12.1 U	R
Arsenic	40	1.6	No	15.6	12.4	15.6	11.5
Barium	--	19,000	No	175	166	175	106
Beryllium	--	200	No	1.8	1.5	1.8	0.91
Cadmium	0.24	81	No	3.5	0.97	1.2	3.5
Chromium	--	1,400	No	23.6	21.2	23.6	18
Cobalt	--	30	No	9.9	8.4	9.3	9.9
Copper	16	4,100	No	59.7	28.1	33.6	59.7
Iron	15,248	72,000	No	20700	16100	19500	20700
Lead	11.6	800	No	104	17.2	23.5	104
Manganese	336	2,300	No	720	198	258	720
Mercury	0.08	31	No	0.15 U	0.11 U	0.145 U	R
Nickel	--	2,000	No	18.8	16.8	18.8	10.4
Selenium	0.07	510	No	7.1 U	6.75 U	7.05 U	R
Silver	--	510	No	2.0 U	1.95 U	2 U	R
Thallium	--	6.6	No	5.1 U	4.85 U	5.05 U	R
Vanadium	--	520	No	39.7	24.1	27.8	39.7
Zinc	46.9	31,000	No	454	81.4	102	454

Chemical (mg/kg dry wt)	Sediment Screening Criteria: Background	Industrial RSL	Exceeds Screening Level?[a]	Lower Lake: Max	LL_1	LL_2	LL_3
Aluminum	--	99,000	No	13000	4440	13000	11500
Antimony	--	41	Yes	990	990	353	530
Arsenic	40	1.6	Yes	3030	1660	2730	3030
Barium	--	19,000	No	245	173	245	205
Beryllium	--	200	No	1.8	0.56	1.8	1.3
Cadmium	0.24	81	Yes	2680	1230	1150	2680
Chromium	--	1,400	No	22.1	10.4	22.1	21.9
Cobalt	--	30	Yes	35.1	25.6	35.1	34.6
Copper	16	4,100	No	2600	1920	1900	2600
Iron	15,248	72,000	No	35200	17500	35200	30300
Lead	11.6	800	Yes	14400	9470	9420	14400
Manganese	336	2,300	No	1370	851	1230	1370
Mercury	0.08	31	Yes	53.3	53.3	38	48.4
Nickel	--	2,000	No	36.4	24.7	36.4	34
Selenium	0.07	510	No	432	432	221	316
Silver	--	510	No	141	101	93.7	141
Thallium	--	6.6	Yes	1980	1980	700	884
Vanadium	--	520	No	57.7	20.4	57.7	44.4
Zinc	46.9	31,000	No	6930	4490	6080	6930

Table A-3 (cont.)

Chemical (mg/kg dry wt)	Sediment Screening Criteria: Background	Industrial RSL	Exceeds Screening Level?[a]	Prickly Pear Creek: Max	PPC_2	PPC_3	PPC_4	PPC_5
Aluminum	--	99,000	No	10100	7750	9500	10100	4880
Antimony	--	41	No	4.5	7.75 *U*	4.1	4.5	1.9
Arsenic	40	1.6	**Yes**	250	52.1	122	250	32.1
Barium	--	19,000	No	352	135	250	352	85.3
Beryllium	--	200	No	1.4	1.1	1.3	1.4	0.63
Cadmium	0.24	81	No	36.8	6	22.8	36.8	4.1
Chromium	--	1,400	No	21.2	10.3	15.9	21.2	8.2
Cobalt	--	30	No	21.2	12.3	15.5	21.2	7
Copper	16	4,100	No	480	93.9	221	480	44.1
Iron	15,248	72,000	No	38100	18600	24800	38100	11800
Lead	11.6	800	**Yes**	1090	370	878	1090	203
Manganese	336	2,300	**Yes**	9030	672	3920	9030	558
Mercury	0.08	31	No	3.1	0.43	2.5	3.1	0.27
Nickel	--	2,000	No	16.1	9.9	12.7	16.1	6.2
Selenium	0.07	510	No	5.3	1.3	2.8	5.3	1.1
Silver	--	510	No	2.5	1.3 *U*	0.85	2.5	1.2 *U*
Thallium	--	6.6	No	3.3 *U*	3.25 *U*	*R*	*R*	3 *U*
Vanadium	--	520	No	55.2	34	44.1	55.2	24.8
Zinc	46.9	31,000	No	3930	925	1860	3930	444

Chemical (mg/kg dry wt)	Sediment Screening Criteria: Background	Industrial RSL	Exceeds Screening Level?[a]	Upper Lake/Marsh Area: Max	ULM_1	ULM_2	ULM_3	ULM_4	ULM_5	ULM_6
Aluminum	--	99,000	No	20000	15700	14500	15700	11900	9490	20000
Antimony	--	41	**Yes**	112	19.5	1.7	5.6	16.8	10.9	68.6
Arsenic	40	1.6	**Yes**	581	229	121	162	116	124	326
Barium	--	19,000	No	282	150	213	282	143	111	228
Beryllium	--	200	No	2.1	1.5	1.9	2.1	1.2	1	1.9
Cadmium	0.24	81	**Yes**	338	112	12.2	66.9	42.5	46.6	199
Chromium	--	1,400	No	27.3	19.5	20.5	22.3	15.6	13.1	26.7
Cobalt	--	30	No	24.1	12.2	17.5	19.2	11.5	9.1	18.8
Copper	16	4,100	No	2290	686	191	430	404	332	1270
Iron	15,248	72,000	No	34400	23500	32600	29200	18400	16000	34400
Lead	11.6	800	**Yes**	10400	4270	594	1470	1170	1610	5360
Manganese	336	2,300	**Yes**	2520	720	2520	955	576	484	747
Mercury	0.08	31	**Yes**	59.1	14.2	0.59	4.7	5.9	14.5	27.3
Nickel	--	2,000	No	24.8	17.9	16.2	20.1	12.1	10.1	22.5
Selenium	0.07	510	No	20.4	14	2.8	4.3	4.5	3.8	14
Silver	--	510	No	127	29.1	0.65	10.2	14	11.9	59.3
Thallium	--	6.6	No	5.25	1.9	*R*	*R*	5.25	4.15 *U*	4.8
Vanadium	--	520	No	59.4	41.9	56.2	50.4	34	34.3	58.9
Zinc	46.9	31,000	No	6550	1810	1680	3540	2100	1680	4200

Table A-3 (cont.)

Chemical (mg/kg dry wt)	Upper Lake/Marsh Area						
	ULM_7	ULM_8	ULM_9	ULM_10	ULM_11	ULM_12	ULM_12
Aluminum	9650	12200	15600	14200	17500	15900	15900
Antimony	1.2	6.5	0.43	60	112	64.9	64.9
Arsenic	54.6	297	146	337	581	452	452
Barium	120	149	214	179	201	228	228
Beryllium	1	1.3	1.7	1.6	2	2	2
Cadmium	15	38.3	17.7	238	338	316	316
Chromium	12.4	15.8	20.9	20.1	27.3	24.7	24.7
Cobalt	8.6	13.6	17.4	18	24.1	21.5	21.5
Copper	158	391	180	1310	2290	1970	1970
Iron	16300	19300	26200	25600	30200	29300	29300
Lead	486	1850	529	5140	10400	8990	8990
Manganese	472	890	755	911	1300	1190	1190
Mercury	1.2	10.1	2.1	28.3	50.6	59.1	59.1
Nickel	9.3	13.4	17.9	19.6	24.8	23	23
Selenium	3.2	5.2	2.9	11.5	19.9	20.4	20.4
Silver	2.7	14.2	1.3 *U*	64.1	127	107	107
Thallium	4.25 *U*	3.3 *U*	3.2 *U*	*R*	*R*	*R*	*R*
Vanadium	27.1	46.2	57.5	43.6	59.4	52.4	52.4
Zinc	1360	2120	1670	4260	6550	6420	6420

Notes:

R - Rejected

U - not detected, reported at half the detection limit.

Units are mg/kg dry weight.

[a] Industrial screening levels are based on either the EPA Regional Screening Level (RSL) for industrial soil exposure or Montana Background, whichever is greater. RSLs based on noncarcinogenic effects were divided by 10, with the exception of the lead screening level. Background is based on mean soil concentrations from Helena Valley (MDEQ 2007). The arsenic background concentration represents the 95%UCL on the mean of background soil arsenic concentrations in Montana (MDEQ 2005).

Table A-4. Detailed results of human health screening of surface water

Chemical	Surface Water Screening Criteria MCL	MWQS	RSL	Exceeds Screening Level?	Max		Reference CFR_1 2003	CFR_2 2003	PPC_1 2003	PPC-3A 10/24/08	PPC-3A 04/30/08
Total metals (ug/L)											
Aluminum	--	--	3,700	**Yes**	6880		6880	5770	100	*U*	100
Antimony	6	5.6	1.5	**Yes**	30		6.9	30	*U*	10.9	2.5 *U*
Arsenic	10	10	0.0045	**Yes**	14.8		14.8	11.5	7.5	*U*	4	4
Barium	2,000	2,000	730	No	125		125	119	100	*U*		50 *U*
Beryllium	4	4	7.3	No	2.5		0.52	0.43	2.5	*U*		0.5 *U*
Cadmium	5	5	1.8	No	0.52		0.17	0.52	0.5	*U*	0.5 *U*	0.5 *U*
Chromium	100	100	5,500	No	6.5		6.5	5.7	5	*U*		0.5 *U*
Cobalt	--	--	1.1	**Yes**	25.0		2.2	2.1	25	*U*		5 *U*
Copper	1,300	1,300	150	No	10.8		7.5	10.8	4.5		2 *U*	2 *U*
Iron	--	--	2,600	**Yes**	5760		5760	5370	191		150	380
Lead	15	15	--	No	14.9		3.9	14.9	5	*U*	2.5 *U*	2.5 *U*
Manganese	--	--	88	No	63.5		63.5	61.1	20.3		40	60
Mercury	2	0.05	1.1	ND>	3	*U*						3 *U*
Nickel	--	--	73	No	5.7		4.9	5.7	20	*U*		5 *U*
Selenium	50	50	18	No	13.7		9.6	13.7	17.5	*U*	2.5 *U*	2.5 *U*
Silver	--	100	18	No	0.81		*R*	0.81	5	*U*		2.5 *U*
Thallium	2	0.24	0.29	ND>	12.5	*U*	12.5 *U*	12.5 *U*	12.5	*U*		1 *U*
Vanadium	--	--	18	No	15.5		15.5	14.1	25	*U*		5 *U*
Zinc	--	2,000	1,100	No	118		103	118	80.9		60	50
Hardness (mg/L)					194		194	193	58.1			

Chemical	Surface Water Screening Criteria MCL	MWQS	RSL	Exceeds Screening Level?	Max		Lower Lake LL_1 2003	LL_2 2003	LL_3 2003	Lower Lake 10/24/08	Lower Lake 04/30/08
Total metals (ug/L)											
Aluminum	--	--	3,700	No	100	*U*	100 *U*	100	*U*	100 *U*		50 *U*
Antimony	6	5.6	1.5	**Yes**	437		375	423	437		260
Arsenic	10	10	0.0045	**Yes**	243		221	239	242	243	67
Barium	2,000	2,000	730	No	43.9		38.3	43.4	43.9		50 *U*
Beryllium	4	4	7.3	No	2.5	*U*	2.5 *U*	2.5	*U*	2.5 *U*		0.5 *U*
Cadmium	5	5	1.8	**Yes**	8.9		8.2	8.3	8.9	3	4
Chromium	100	100	5,500	No	1.0		1	0.67	0.9		0.5 *U*
Cobalt	--	--	1.1	ND>	25.0	*U*	25 *U*	25	*U*	25 *U*		5 *U*
Copper	1,300	1,300	150	No	31.8		26.8	30.1	31.8	12	19
Iron	--	--	2,600	No	450		356	400	442	370	450
Lead	15	15	--	**Yes**	87.1		65.9	78.9	87.1	41	55
Manganese	--	--	88	**Yes**	224		204	221	224	140	140
Mercury	2	0.05	1.1	ND>	3.0	*U*					3 *U*
Nickel	--	--	73	No	4.3		20 *U*	3.9	4.3		5 *U*
Selenium	50	50	18	**Yes**	54.1		48.1	50.4	54.1	37	34
Silver	--	100	18	No	2.1		2.1	1.2	5	*U*		2.5 *U*
Thallium	2	0.24	0.29	**Yes**	77.0		65.7	66	67.5		77
Vanadium	--	--	18	ND>	25.0	*U*	25 *U*	25	*U*	25 *U*		5 *U*
Zinc	--	2,000	1,100	No	125		77.5	125	123	10 *U*	40

Table A-4 (cont.)

Chemical	Surface Water Screening Criteria MCL	MWQS	RSL	Exceeds Screening Level?	Prickly Pear Creek Max	PPC_2 2003	PPC_3 2003	PPC_4 2003	PPC_5 2003	PPC-103 10/24/08	PPC-103 04/30/08
Total metals (ug/L)											
Aluminum	--	--	3,700	No	100 U	100 U	100 U	100 U	100 U		50 U
Antimony	6	5.6	1.5	ND>	30 U	30 U	30 U	30 U	30 U		2.5 U
Arsenic	10	10	0.0045	**Yes**	11.5	7.5 U	11.5	10.1	7.5 U	6	6
Barium	2,000	2,000	730	No	49.5	29.3	27.6	27.9	49.5		50 U
Beryllium	4	4	7.3	No	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U		0.5 U
Cadmium	5	5	1.8	No	0.36	0.21	0.36	0.29	0.11	0.5 U	0.5 U
Chromium	100	100	5,500	No	5.0 U	5 U	5 U	5 U	5 U		0.5 U
Cobalt	--	--	1.1	ND>	25 U	25 U	25 U	25 U	25 U		5 U
Copper	1,300	1,300	150	No	6	5	4.7	4.4	4.3	2 U	2 U
Iron	--	--	2,600	No	380	269	368	327	90	330	300
Lead	15	15	--	No	9	4.1	4.7	4.9	5 U	2.5 U	2.5 U
Manganese	--	--	88	**Yes**	90	56.2	89	67.5	15.9	80	70
Mercury	2	0.05	1.1	ND>	3 U						3 U
Nickel	--	--	73	No	20 U	20 U	20 U	20 U	20 U		5 U
Selenium	50	50	18	No	17.5 U	17.5 U	17.5 U	17.5 U	17.5 U	2.5 U	2.5 U
Silver	--	100	18	No	5.0 U	5 U	5 U	5 U	5 U		2.5 U
Thallium	2	0.24	0.29	ND>	12.5 U	12.5 U	12.5 U	12.5 U	12.5 U		1 U
Vanadium	--	--	18	ND>	25 U	25 U	25 U	25 U	25 U		5 U
Zinc	--	2,000	1,100	No	94.7	65.3	86.9	68.2	94.7	70	40

Chemical	Prickly Pear Creek PPC-5 10/24/08	PPC-5 04/30/08	PPC-7 10/24/08	PPC-7 04/30/08	PPC-8 10/24/08	PPC-8 04/30/08
Total metals (ug/L)						
Aluminum		50 U		50 U		50 U
Antimony		2.5 U		2.5 U		2.5 U
Arsenic	6	6	8	7	8	7
Barium		50 U		50 U		50 U
Beryllium		0.5 U		0.5 U		0.5 U
Cadmium	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chromium		0.5 U		0.5 U		0.5 U
Cobalt		5 U		5 U		5 U
Copper	2 U	5	2 U	2 U	2 U	6
Iron	350	320	310	330	300	380
Lead	2.5 U	5	2.5 U	6	2.5 U	9
Manganese	90	70	80	70	80	90
Mercury		3 U		3 U		3 U
Nickel		5 U		5 U		5 U
Selenium	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U
Silver		2.5 U		2.5 U		2.5 U
Thallium		1 U		1 U		1 U
Vanadium		5 U		5 U		5 U
Zinc	70	40	70	40	70	50

Table A-4 (cont.)

Chemical	Surface Water Screening Criteria MCL	MWQS	RSL	Exceeds Screening Level?	Max	ULM_1 2003	ULM_2 2003	ULM_3 2003	ULM_4 2003	ULM_5 2003	ULM_6 2003
Total metals (ug/L)											
Aluminum	--	--	3,700	No	1620	132	828	100 U	100 U	1620	168
Antimony	6	5.6	1.5	ND>	30 U	30 U	30 U	30 U	30 U	30 U	30 U
Arsenic	10	10	0.0045	Yes	31.5	7.5 U	21.4	7.5 U	9.1	14.4	10.3
Barium	2,000	2,000	730	No	63.5	14.6	63.5	32.2	32	45.9	27.2
Beryllium	4	4	7.3	No	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U
Cadmium	5	5	1.8	Yes	5.6	0.21	2.1	0.44	0.11	2.9	0.25
Chromium	100	100	5,500	No	4.1	5 U	2.9	0.67	5 U	1.9	4.1
Cobalt	--	--	1.1	Yes	2.7	25 U	2.7	25 U	25 U	1.1	25 U
Copper	1,300	1,300	150	No	27.7	4	23.4	4.1	4	27.7	7.9
Iron	--	--	2,600	Yes	8370	120	4560	265	293	2040	215
Lead	15	15	--	Yes	156	6.9	57.6	16.5	5 U	115	19.9
Manganese	--	--	88	Yes	2180	47.6	2180	70.8	85.2	241	40.7
Mercury	2	0.05	1.1								
Nickel	--	--	73	No	20 U	20 U	20 U	20 U	20 U	20 U	20 U
Selenium	50	50	18	No	17.5 U	17.5 U	17.5 U	17.5 U	17.5 U	17.5 U	17.5 U
Silver	--	100	18	No	0.94	5 U	5 U	0.86	5 U	R	0.81
Thallium	2	0.24	0.29	ND>	12.5 U	12.5 U	12.5 U	12.5 U	12.5 U	12.5 U	12.5 U
Vanadium	--	--	18	No	5.6	2.7	5.6	25 U	25 U	3.9	25 U
Zinc	--	2,000	1,100	No	253	27.4	253	30 U	30 U	140	30 U

Chemical	ULM_7 2003	ULM_8 2003	ULM_9 2003	ULM_10 2003	ULM_11 2003	ULM_12 2003
Total metals (ug/L)						
Aluminum	100 U	100 U	100 U	100 U	100 U	294
Antimony	30 U	30 U	30 U	30 U	30 U	30 U
Arsenic	7.5 U	31.5	7.5 U	7.7	7.5 U	8.4
Barium	26.8	58.9	35.4	34.2	35	45.5
Beryllium	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U
Cadmium	0.18	3.1	1.4	0.85	1.1	5.6
Chromium	0.96	2.4	1.1	5 U	0.69	0.89
Cobalt	25 U	25 U	25 U	25 U	25 U	25 U
Copper	3.8	21.5	13.4	5.4	8.3	22.1
Iron	230	8370	1000	283	201	603
Lead	5 U	68.4	20.6	31.6	28.2	156
Manganese	49.5	1740	382	90.1	79.2	97.9
Mercury						
Nickel	20 U	20 U	20 U	20 U	20 U	20 U
Selenium	17.5 U	17.5 U	17.5 U	17.5 U	17.5 U	17.5 U
Silver	5 U	0.8	5 U	5 U	R	0.94
Thallium	12.5 U	12.5 U	12.5 U	12.5 U	12.5 U	12.5 U
Vanadium	25 U	3.2	25 U	25 U	25 U	25 U
Zinc	30 U	127	59.3	30 U	31.9	97.9

Table A-4 (cont.)

Chemical	Surface Water Screening Criteria MCL	MWQS	RSL	Exceeds Screening Level?	Upper Lake Max	Upper Lake 11/07/02
Total metals (ug/L)						
Aluminum	--	--	3,700			
Antimony	6	5.6	1.5			
Arsenic	10	10	0.0045	**Yes**	30	30.0
Barium	2,000	2,000	730			
Beryllium	4	4	7.3			
Cadmium	5	5	1.8	**Yes**	30	30.0
Chromium	100	100	5,500			
Cobalt	--	--	1.1			
Copper	1,300	1,300	150	No	90	90.0
Iron	--	--	2,600	No	1700	1700
Lead	15	15	--	**Yes**	800	800
Manganese	--	--	88	**Yes**	200	200
Mercury	2	0.05	1.1			
Nickel	--	--	73			
Selenium	50	50	18			
Silver	--	100	18			
Thallium	2	0.24	0.29			
Vanadium	--	--	18			
Zinc	--	2,000	1,100	No	300	300

Chemical	Surface Water Screening Criteria MCL	MWQS	RSL	Exceeds Screening Level?	Wilson Ditch Max	WD-1 06/20/02	WD-2 06/20/02	WD-2 06/04/01
Total metals (ug/L)								
Aluminum	--	--	3,700					
Antimony	6	5.6	1.5					
Arsenic	10	10	0.0045	No	10.0	10.0	7.0	5.0
Barium	2,000	2,000	730					
Beryllium	4	4	7.3					
Cadmium	5	5	1.8	No	3.0	3.0	2.0	1.0
Chromium	100	100	5,500					
Cobalt	--	--	1.1					
Copper	1,300	1,300	150	No	10.0	10.0	7.0	4.0
Iron	--	--	2,600	No	300	200	300	300
Lead	15	15	--	**Yes**	60.0	60.0	30.0	7.0
Manganese	--	--	88	No	60.0	40.0	60.0	60.0
Mercury	2	0.05	1.1					
Nickel	--	--	73					
Selenium	50	50	18					
Silver	--	100	18					
Thallium	2	0.24	0.29					
Vanadium	--	--	18					
Zinc	--	2,000	1,100	No	100	40.0	100.000001	30.0

U - not detected, value represents detection limit

[a]If there is a maximum contaminant level (MCL) for a metal, the MCL is used as the surface water screening level. If there is not an MCL, the surface water screening level is the lesser of the Montana Water Quality Standard (MWQS) for human health and the EPA Regional Screening Level (RSL) for tap water. RSLs based on noncarcinogenic effects were divided by 10, with the exception of the lead screening level. All metals that did not exceed an MCL also met the MWQS.

Table A-5. Detailed results of human health screening of private well groundwater

Analyte	Number of Analyses	Number of Detected Values	Site Maximum Concentration		Groundwater Screening Level[a]	Exceeds Groundwater Screening Level?	Basis for Screening Level[b]
Dissolved metals (mg/L)							
Aluminum	192	0	0.05	*U*	3.7	No	RSL
Antimony	192	1	0.0015		0.006	No	MCL
Arsenic	300	112	0.052		0.01	**Yes**	MCL
Barium	192	3	0.058		2	No	MCL
Beryllium	192	0	0.0005	*U*	0.004	No	MCL
Cadmium	300	10	0.002		0.005	No	MCL
Chromium	192	23	0.002	*U*	0.1	No	MCL
Cobalt	192	0	0.005	*U*	0.0011	ND>	RSL
Copper	300	129	0.087		1.3	No	MCL
Iron	300	72	0.6		2.6	No	RSL
Lead	300	0	0.003	*U*	0.015	No	MCL
Manganese	300	37	0.03		0.088	No	RSL
Mercury	192	0	0.003	*U*	0.002	ND>	MCL
Nickel	192	3	0.0038		0.073	No	RSL
Selenium	300	161	0.34		0.05	**Yes**	MCL
Silver	189	0	0.003	*U*	0.018	No	RSL
Thallium	192	2	0.002		0.002	No	MCL
Tin	68	0	0.1	*U*	2.2	No	RSL
Vanadium	192	10	0.02		0.018	**Yes**	RSL
Zinc	300	79	0.056		1.1	No	RSL

Notes:

Undetected results are reported at half the detection limit

-- - No screening level was available for this chemical.

U - not detected in any sample

ND> - not detected in any sample, but the detection limit exceeded the screening level

[a] If there is a maximum contaminant level (MCL) for a metal, the MCL is used as the groundwater screening level. If there is not an MCL, the groundwater screening level is the lesser of the Montana Water Quality Standard (MWQS) for human health and the EPA Regional Screening Level (RSL) for tap water. RSLs based on noncarcinogenic effects were divided by 10, with the exception of the lead screening level. In all cases the MWQS values are greater than or equal to the MCL.

[b] Basis for screening level: MCL=maximum contaminant level; RSL=EPA Regional Screening Level

Table A-6. Detailed results of human health screening of monitoring well groundwater

Chemical	Number of Analyses	Number of Detected Values	Site Maximum Concentration		Groundwater Screening Level[a]	Exceeds Groundwater Screening Level?	Basis for Screening Level[b]	Criteria values: National Primary Drinking Water MCL	Criteria values: EPA Regional Screening Level (RSL) for Tap Water	Criteria values: Montana Water Quality Standard for Human Health
Dissolved metals (mg/L)										
Aluminum	475	33	2.3		3.7	No	RSL		3.7	
Antimony	475	96	0.21		0.006	**Yes**	MCL	0.006	0.0015	0.006
Arsenic	1057	872	253		0.01	**Yes**	MCL	0.01	0.0000045	0.01
Barium	475	49	0.3		2	No	MCL	2	0.73	2
Beryllium	475	19	0.004		0.004	No	MCL	0.004	0.0073	0.004
Cadmium	1052	224	5.92		0.005	**Yes**	MCL	0.005	0.0018	0.005
Chromium	475	46	0.007		0.1	No	MCL	0.1	5.5	0.1
Cobalt	475	86	0.08		0.0011	**Yes**	RSL		0.0011	
Copper	1052	227	0.626		1.3	No	MCL	1.3	0.15	1.3
Iron	1052	406	199		2.6	**Yes**	RSL		2.6	
Lead	1052	41	0.83		0.015	**Yes**	MCL	0.015		0.015
Manganese	1052	566	23.54		0.088	**Yes**	RSL		0.088	
Mercury	475	40	0.006		0.002	**Yes**	MCL	0.002	0.0011	0.002
Nickel	475	59	0.07		0.073	No	RSL		0.073	
Selenium	999	749	3.35		0.05	**Yes**	MCL	0.05	0.018	0.05
Silver	458	2	0.006		0.018	No	RSL		0.018	0.1
Thallium	475	51	0.467		0.002	**Yes**	MCL	0.002	0.00029	0.002
Tin	57	0	0.1	*U*	2.2	No	RSL		2.2	
Vanadium	475	58	0.03		0.018	**Yes**	RSL		0.018	
Zinc	1052	330	24.46		1.1	**Yes**	RSL		1.1	2
Total metals (mg/L)										
Aluminum	37	27	11.4		3.7	**Yes**	RSL		3.7	
Antimony	37	16	0.095		0.006	**Yes**	MCL	0.006	0.0015	0.006
Arsenic	135	131	212		0.01	**Yes**	MCL	0.01	0.0000045	0.01
Barium	37	9	0.3		2	No	MCL	2	0.73	2
Beryllium	37	6	0.003		0.004	No	MCL	0.004	0.0073	0.004
Cadmium	135	109	7.13		0.005	**Yes**	MCL	0.005	0.0018	0.005
Chromium	37	14	0.015		0.1	No	MCL	0.1	5.5	0.1
Cobalt	37	8	0.07		0.0011	**Yes**	RSL		0.0011	
Copper	135	102	0.957		1.3	No	MCL	1.3	0.15	1.3
Iron	135	133	217		2.6	**Yes**	RSL		2.6	
Lead	135	73	2.78		0.015	**Yes**	MCL	0.015		0.015
Manganese	135	131	25		0.088	**Yes**	RSL		0.088	
Mercury	37	0	0.003	*U*	0.002	ND>	MCL	0.002	0.0011	0.002
Nickel	37	8	0.07		0.073	No	RSL		0.073	
Selenium	121	82	1.34		0.05	**Yes**	MCL	0.05	0.018	0.05
Silver	37	3	0.012		0.018	No	RSL		0.018	0.1

Table A-6. (cont.)

Chemical	Number of Analyses	Number of Detected Values	Site Maximum Concentration		Groundwater Screening Level[a]	Exceeds Groundwater Screening Level?	Basis for Screening Level[b]	Criteria values: National Primary Drinking Water MCL	Criteria values: EPA Regional Screening Level (RSL) for Tap Water	Criteria values: Montana Water Quality Standard for Human Health
Total metals (mg/L) (cont.)										
Thallium	37	10	0.231		0.002	**Yes**	MCL	0.002	0.00029	0.002
Tin	13	0	0.05	*U*	2.2	No	RSL		2.2	
Vanadium	37	8	0.04		0.018	**Yes**	RSL		0.018	
Zinc	135	119	27.6		1.1	**Yes**	RSL		1.1	2

Notes:

-- - No screening level was available for this chemical.

U - not detected in any sample

ND> - not detected in any sample, but the detection limit exceeded the screening level

[a] If there is a maximum contaminant level (MCL) for a metal, the MCL is used as the groundwater screening level. If there is not an MCL, the groundwater screening level is the lesser of the Montana Water Quality Standard (MWQS) for human health and the EPA Regional Screening Level (RSL) for tap water. RSLs based on noncarcinogenic effects were divided by 10, with the exception of the lead screening level. In all cases the MWQS values are greater than or equal to the MCL.

[b] Basis for screening level:
MCL=maximum contaminant level;
RSL=EPA Regional Screening Level